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The Month.

The Salisbury Railway Disaster.—When the news arrived that the American boat train had been wrecked at Salisbury Station, railway engineers were prepared at once to believe that the derailment which caused the disaster might reasonably be attributed to excessive speed round the curve just beyond the station. Of course, this was not the only possible hypothesis, for the accident might have been attributable to some defect in or obstruction on the permanent way, or to the sudden fracture of a rail, wheel, or axle. But those who knew the excellent condition of the London and South Western main line, and the high class character of the rolling-stock, were generally disinclined to accept as probable any theory based upon faults or accidental breakage, although admitting their possibility.

Our contemporary, *The Engineer*, was not disposed at first to the view that excessively high speed could be the cause of the accident. In a leading article dated July 6th, our contemporary referred to a description by Mr. Rous-Marten of a record run made by the same boat train in 1904, to support the suggestion that the train was always run at very high speeds through Salisbury Station, and then proceeded to argue that high speeds are far safer than slow speeds, that high speed alone is not a sufficient explanation of a derailment, that the train in question had probably gone safely through the station at a speed as high as that attained on the morning of the accident, and that we had to look for some other cause, such as the rolling of the engine, unsteady and irresponsible action of the bogie, worn flanges, excessive side pressure due to the curve of the rails, some obstacle on the line, a broken rail, a broken axle,

and so on. The article went on, in terms of almost pathetic despair, to say that something else "must be found" besides high speed, and it opened anew the list of alternative causes of derailment for the inclusion faulty signals, a defective bridge, fog accidents, a signalman's or driver's error, as things we could set about correcting. The article concluded with the opinion that "it would be far more satisfactory to know that the accident was due to a broken axle or to any other definite cause than to have vague statements about excessive speed, and it is not unlikely that some such cause will be found."

Judging from the laboured defence of high speeds contained in the leader to which we refer, it seems not improbable that it was written by Mr. Rous-Marten himself, a gentleman who has contributed to *The Engineer* an exceedingly voluminous series of articles largely dedicated to the advertisement of record runs on various railways. At any rate it placed our contemporary in a very awkward position, for all the expert and other evidence given at the coroner's inquest directly contradicts the suggestion that the boat train was usually run at high speed through Salisbury Station, and demonstrates conclusively that the accident was due simply to excessive speed.

Dealing first with the regulations of the company, we may refer to the evidence of Mr. F. C. French, chief assistant to Mr. Dugald Drummond, and of Mr. Henry Holmes, the traffic superintendent. The former witness produced the copy of an order, issued in April, 1904, limiting the speed of non-stopping trains through Salisbury to thirty miles an hour, and said that the driver of the wrecked train had signed a copy of the order, according to the usual custom. This regulation was supplemented by working time sheets—posted in every running shop on the line—which by giving additional time between the east and west boxes at Salisbury, further reduced the speed to twenty-six miles an hour on the curve. Mr. Holmes corroborated this evidence, and the local traffic inspector stated that the usual speed through the station was only twenty-five miles an hour.

These facts prove that every department of the company responsible for the conduct of traffic had taken all necessary and reasonable steps to provide for safe working and quite dispose of the reckless assertions made in the article published by our contemporary.

With regard to the actual speed attained by the boat train on the morning of the disaster, we may dismiss the speed estimates of the guard, the traffic inspector, and the signalman at Salisbury west box, and take that calculated by Mr. Holmes from the times booked in the signal cabins along the line.

Mr. Holmes found that the speeds worked out as follows:—

Section of Line.	Length in Miles.	Speed in Miles per Hour.
Tisbury to Dinton	4·29	... 64·3
Dinton to Wilton	5·83	... 69·9
Wilton to Salisbury (West)	2·29	... 68·5

It should be pointed out that for about half the distance beyond Wilton there is an up gradient naturally causing diminution of speed, while the remainder of the section is on a down gradient of 1 in 115, so that to account for the average speed of 68·5 miles an hour the train probably travelled at the rate of at least 70 miles an hour between the west box and the point where the accident occurred.

If the driver had put on his vacuum brake, in addition to shutting off steam, the speed of the train could easily have been reduced to the limit imposed by the regulations. But there is direct evidence to show that his brake was not applied. The guard stated that the brake was not put on as customarily when the train approached the west end of the station platform, and Mr. French found on examination of the wrecked engine that the vacuum brake was still in the "running" position. Hence we are confronted with the fact that the driver endeavoured to negotiate the curve at a speed of very little, if any, less than 70 miles an hour, which apparently was thought by the writer of the leader of July 6th to *The Engineer*, to be not only the usual speed of the boat train, but as one that would "have a steadying effect," and could not be "a sufficient explanation of a derailment." Since the publication of the verdict returned by the coroner's jury, we are pleased to see that our contemporary has been obliged to admit that the engine was overturned by the high rate of speed maintained round the curve, although still clinging to the untenable suggestion that the train had probably passed safely round the same curve at speeds as great if not greater than 70 miles an hour.

The futility of any such hypothesis is readily demonstrated by the aid of facts and figures furnished by the evidence of Mr. Jacomb-Hood as to the design of the curve, and of Mr. Holmes as to the actual speed of the train. Mr. Hood said the curve in question is a compound one, of 12 chains radius, and of 8 chains radius at its sharpest part; that the super-elevation of the outer rail was 3½ in., which, under

local conditions, was the most that could be given; and that the curve was perfectly safe for speeds up to 30 miles an hour.

Two simple calculations will serve to show the approximate condition of stability at the speeds of 30 miles and 70 miles an hour respectively on the Salisbury curve. The following are the necessary data:—

(W)	Weight of locomotive	54	tons.
(v)	Velocity (30 miles an hour) ...	44	ft. per second.
(v)	" (70 ") ...	102·66	ft. "
(g)	Force of gravity	32·2	ft. "
(R)	Radius of curve	528	ft.
(h)	Height of centre of gravity of engine above rail level ...	58·5	in.
(l)	Horizontal distance between vertical line through centre of gravity of engine and outer rail, allowing for 3½ in. super-elevation	31·75	in.

The moment of the weight of the locomotive about the outer rail is obviously $W \times l = 54 \times 31{\cdot}75 = 1714{\cdot}5$ inch tons, and so long as this exceeds the overturning moment due to centrifugal force, the stability of the engine will be assured, but of course it may be in a critical condition in this respect unless an ample margin of safety exists.

At the velocity of 30 miles an hour the centrifugal force (f) developed is

$$f = \frac{W \times v^2}{g \times R} = \frac{54 \times 44^2}{32{\cdot}2 \times 528} = 6{\cdot}15 \text{ tons},$$

and the moment of the force about the outer rail is $f \times h = 6{\cdot}15 \times 58{\cdot}5 = 359{\cdot}77$, say 360 inch-tons. Comparing this value with that of the moment of stability of the engine, it is evident that at the speed of 30 miles an hour, a very ample factor of safety exists.

At the velocity of 70 miles an hour, the the centrifugal force developed is

$$f = \frac{54 \times 102{\cdot}66^2}{32{\cdot}2 \times 528} = 33{\cdot}5 \text{ tons},$$

and the moment of the force about the outer rail is $f \times h$ $33{\cdot}5 \times 58{\cdot}5 = 1{,}960$ inch tons, which, being in excess of the moment of stability of the engine, shows that at the speed of 70 miles an hour round the curve in question it is impossible for the engine to avoid being overthrown.

By calculations similar to the above it would be easy to demonstrate that the velocity giving rise to an overturning moment exactly equal in value to that of the moment of stability for the engine and curve here considered is equal to the speed of about 66·2 miles an hour.

The points we have demonstrated must be evident to all who have any knowledge of mechanical science, although they do not appear to have been grasped by the locomotive expert of *The Engineer*. Why the American boat train should have been run at excessive speed through Salisbury Station, contrary to well-known regulations, no one will ever be able to discover, as the driver was himself a victim of the disaster. One thing abundantly clear is that the London and South Western Railway Company are not morally responsible for the disaster. They had framed judicious regulations which were duly brought to the notice of their employees, and they had placed a steady and competent man in charge of the train. Nothing more could he expected of them, and why the coroner's jury should have thought it necessary to add a rider to their verdict, virtually censuring the company, we cannot imagine. This rider is entirely undeserved, and in every way unreasonable.

The Motor Bus Disaster.—The third lamentable disaster that we have this month to record is that which occurred on Handcross-hill to a "Vanguard" 'bus used temporarily for conveying an excursion party from Orpington to Brighton. From published accounts, it appears that the omnibus was moving at the speed of about twelve miles an hour when it reached the top of the hill. It was under the charge of a duly qualified driver, who has been in the employ of the Vanguard Company since its formation. Soon after passing over the brow of the hill, when the speed had increased to about fourteen miles an hour, the foot brake was applied, but had little or no effect in reducing the speed of the vehicle. About halfway down the hill, the gear-box broke, the Cardan propeller shaft broke away, and being then entirely without controlling mechanism except the hand-brake, the vehicle pursued its way with ever increasing momentum, and finally crashed into a large oak tree. At the present moment it is not clear whether or not the hand brake was used at all; but even if it was, this brake would not be of sufficient power to enable the driver to keep so large a vehicle under control. Until definite evidence has been brought before the Coroner's Court, only those in possession of official information are in a position to say exactly what steps were taken by the driver to control the omnibus, and we have no desire to hazard any conjectures as to the cause of the accident. It is not improbable that the amount of pressure necessary to hold the foot brake against the increasing speed of the 'bus on Handcross-hill may have thrown such a strain upon the mechanism as to break up the gear-box, possibly in consequence of some flaw or unsuspected weakness in the casting to which the brake is

secured. The effect of such a failure would naturally be to set the propeller shaft adrift, and leave the vehicle without adequate means of control. The whole question of motor 'bus brakes will naturally receive the most careful attention as one result of this disaster, but in the meantime there is no occasion for undue alarm, especially as the car in question was being employed for a purpose quite different from that for which it was designed. Even in the comparatively level streets of a large city, huge, top-heavy vehicles are distinctly undesirable, and they are absolutely unsuited for use in country districts where long and steep hills have to be encountered.

Recent Tramway Disasters.—One of the most unfortunate features connected with electric tramways is that while all such vehicles are fitted with brakes that are fully capable (under favourable conditions) of exerting ample control on the steepest gradients in the hands of competent men who are gifted with the quality of self-control, none of these valuable appliances constitutes an infallible safeguard to the travelling public. The explanation is to be found in the old story that in trying circumstances some men will inevitably lose their heads, and do the wrong thing. Of course, there is always the possibility that brakes may be rendered more or less inoperative by greasy rails, or because they are not in proper working order. Quite recently there has been a veritable epidemic of tramway accidents, which, even if they do not prove existing brakes to be inefficient, certainly illustrate conditions under which they become ineffective. At Swindon, it appears from the evidence of the driver of the car that ran away in June last, that the magnetic brake was out of order and had been so reported to the traffic manager, but that nothing was done. Under these circumstances, the driver seems to have thought it his duty to go out with what he believed to be defective braking apparatus. In this case it is not yet clear whether the magnetic brake was actually useless, for the point was brought out in evidence that the rear hand-brake of the car was found after the accident to be locked—presumably by a passenger when the car got beyond control—thus rendering the magnetic brake inoperative. At Highgate, the driver was clearly wrong in first applying the hand brake so as to lock the wheels, and thereby to prevent the action of the magnetic brake. Nevertheless, there is some reason for doubting whether the hand-brake was in proper condition, as more than one witness proved that there had been complaints to the effect that this brake had a distinct tendency to lock the wheels. The Halifax runaway car was fitted with hand, magnetic, and slipper brakes, all of which were applied by the driver, who stuck manfully to his post without being able to reduce speed. In this accident the uselessness of the brakes was attributed to the greasy condition of the track. At Mansfield, where an electric tramcar commenced to back down a steep hill, up which it was taken to the depôt for the purpose of having the hand brake repaired, the magnetic brake failed to operate. This particular mishap shows the desirability of rear track brakes such as those adopted on the Pennycomequick branch of the Plymouth Corporation tramways. Two recent derailments at Kennington come as reminders that magnetic track brakes are useless when a car has left the rails, a disadvantage from which the air track brake is free. The various accidents to which we have alluded show that however excellent tramway brakes may be in theory, all of them are apt to fail in practice. It is no use for the advocates of particular appliances to say that if judicially applied, they are infallible. We want apparatus so designed and arranged that it shall not be within the power of nervous men to take away the safeguard that is supposed to be afforded by braking mechanism. Hand brakes must be designed so that the driver shall be unable to lock the wheels of a car, and so to render the magnetic brake useless. As for slippery tracks, and brakes in a doubtful state of efficiency, these are matters for which the tramway companies and authorities are directly responsible, and if we may judge from recent occurrences, it does not seem to be clearly established that the points in question always receive the amount of attention that they evidently require. Within the next few months we shall probably receive the Board of Trade reports upon most of the tramway accidents that have taken place within the last few weeks, and it is to be hoped that these documents will receive the careful consideration of tramway owners, and also of those responsible for the framing of regulations governing the equipment and operation of electric tramways.

Dover Harbour Works.*

The New Programme of the Dover Harbour Board.

By W. NOBLE TWELVETREES, M.I.Mech.E.

In a previous article the writer gave a general outline of the new scheme formulated by the Dover Harbour Board, acting in co-operation with the South Eastern and Chatham Railway Company, and approved by the Admiralty, subject to the final sanction of Parliament.

The present favourable state of affairs and the full recognition of the existing community of interests between the contracting parties have not been attained without much hard work. Nearly fourteen years ago, when it was decided to make Dover a great naval base, it appeared probable that the residential and commercial interests of the town would suffer severely. That danger was averted as a result of the representations made to Lord Spencer by the Harbour Board with the support of the Right Hon. George Wyndham, the member for the borough.

The next risk was that the Admiralty programme would imperil the future of Dover as a commercial port. This was no idle fear, for the Government naturally took the view that local interests ought to give way entirely to the great imperial project. But on the other side it was claimed that the development of the port need not be checked, and that the commercial harbour could live side by side with the new naval base. To gain this point much labour and long arguments were necessary, and only in 1904 was it settled in a satisfactory manner.

The discussion between the Dover Harbour Board and the Admiralty was due in no small measure to the employment of the harbour as a port of call by the vessels of the Hamburg-American and other important steamship companies. It was contended by the Admiralty that the use of the harbour by such vessels might interfere with torpedo practice, the application of booms across the entrances, and other defensive measures.

The controversy assumed such importance that it was taken up by the Government and the National Defence Committee, and was finally closed by an agreement arrived at by Lord Selborne and Mr. Wyndham, permitting the development of the scheme which is embodied in the Dover Harbour Act, 1906, now awaiting Parliamentary sanction.

It is quite an open secret that the successful upshot of the negotiations was very largely aided by the fact that the Harbour Board possessed the foreshore and the Prince of Wales Pier, and, therefore, had something to give up in return for concessions by the Government. The result was that the Admiralty agreed to extend the lease of the old Admiralty Pier, to grant a long lease of the Admiralty pier extension, and to give the Harbour Board complete control of the additional water area between the Prince of Wales Pier and the Admiralty Pier extension, the Harbour Board on their part giving to the Admiralty the sole right of berthing vessels on the east side of the Prince of Wales Pier and the use of their railway and appliances upon that pier.

The third phase of the problem was to find a *modus vivendi* between the port authorities and the railway companies. Dover has long lacked proper covered station accommodation for Continental passengers. The Transatlantic traffic,

* Articles I. and II. appeared in THE ENGINEERING REVIEW, vol. xiii., pp. 222, 293.

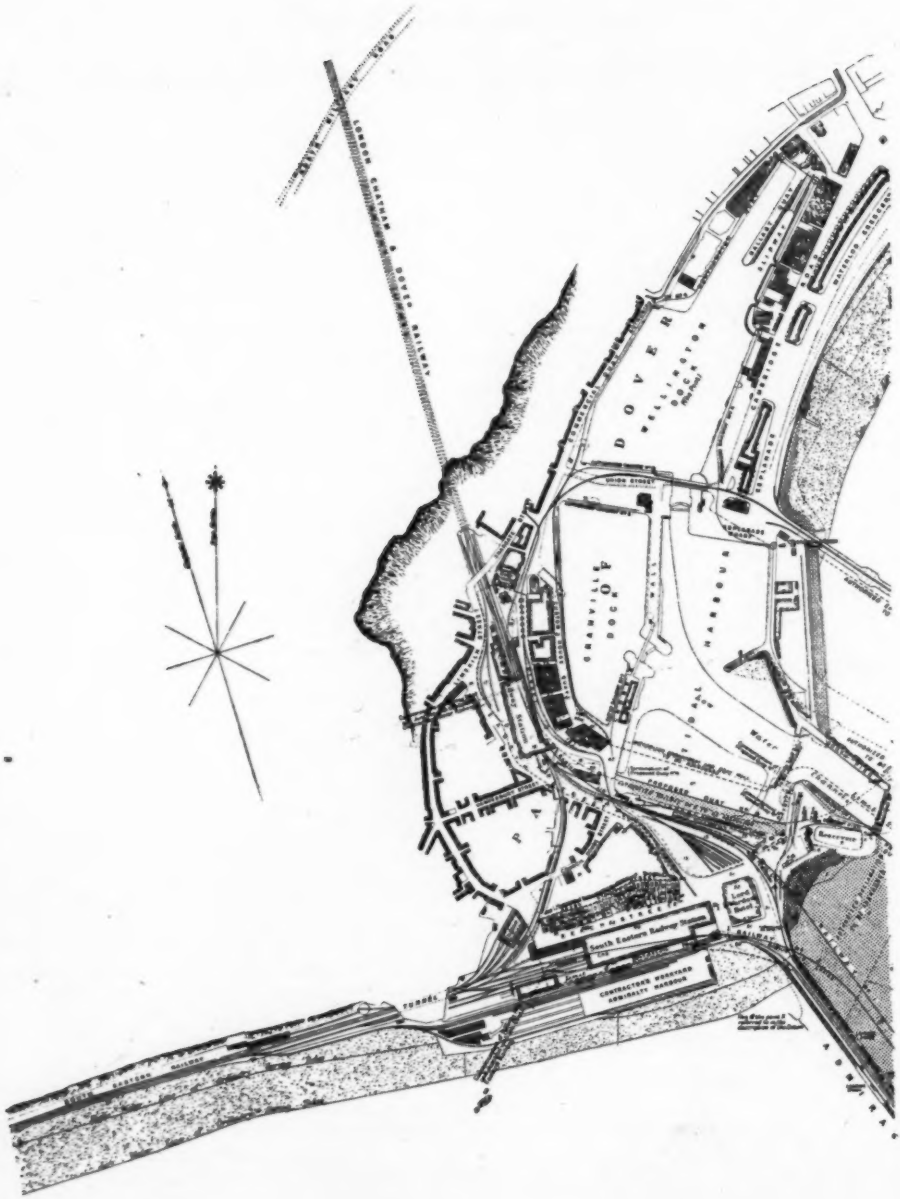
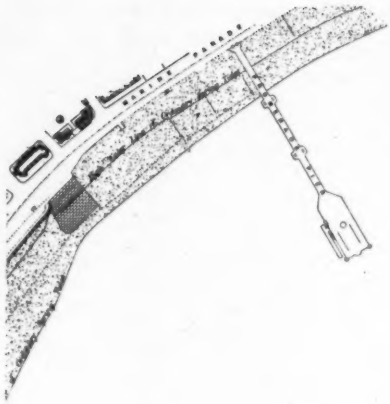

DOVER
Docks
Harbour
Tunnels
Contractors' Workshops
Admiralty Harbour

FIG.



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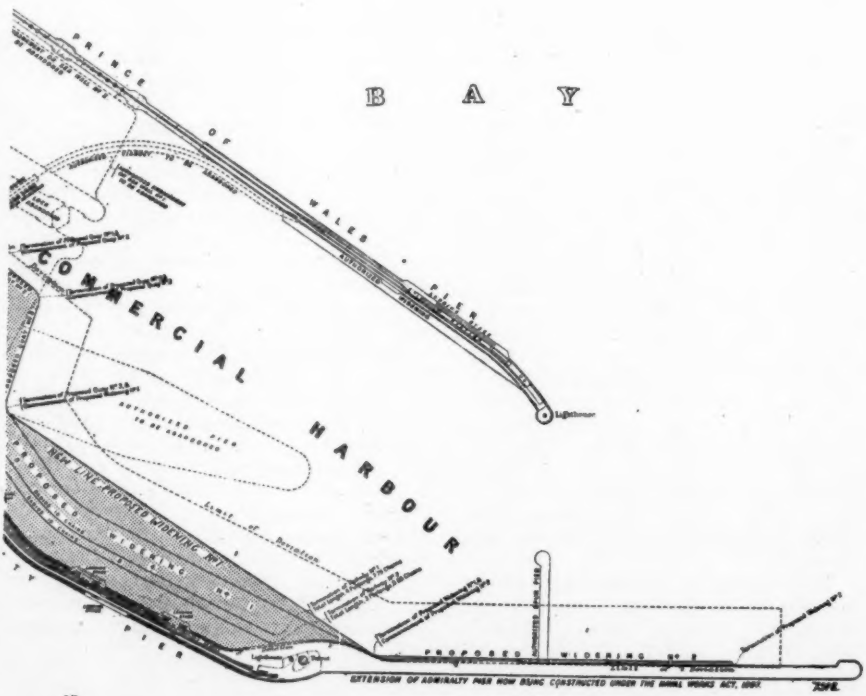

PRINCE
OF
WALES
PIER
COMMERCIAL
HARBOUR
NEW LINE PROPOSED WIDENING 80'
PROPOSED WIDENING No 2
EXTENSION OF ADMIRALTY PIER NOW BEING CONSTRUCTED UNDER THE HARBOUR WORKS ACT, 1897.
ZOPE.

which has grown to such important dimensions since July, 1904, needs more adequate station facilities than those provided upon the Prince of Wales Pier, and the increase of commercial traffic depends very largely upon the addition of quay and warehouse accommodation.

The new programme of the Harbour Board represents a complete agreement between all parties interested, and includes the execution of the important works indicated in Fig. 17, which has been prepared from the plan deposited in Parliament by the Harbour Board with the Bill. Before describing the works in question it should be observed that, subject to the approval of the Board of Trade, the Admiralty, and the South Eastern and Chatham Railway, the Harbour Board will have power to deviate laterally up to the "limit of deviation" shown on the plan. Consequently it is very probable that some modifications may be made in the details of the scheme as there indicated.

Dealing with the new works intended to give additional pier and quay space, we have first that described officially as Widening No. 1, providing for an increase in the width of the old Admiralty Pier from 35 ft. as at present to 275 ft. As shown by Fig. 17, this widening commences at a point nearly opposite the first east landing stage on the pier, some 550 ft. from the corner of the Lord Warden Hotel, and continues for a length of 1,650 ft. This proposal involves a uniform widening and a concave curve for the inner face of the pier, parallel with the outer face. Owing to representations from the South Eastern and Chatham Railway it has now been decided to run the inner face of the widening in a direct line between the starting and finishing points, as indicated in Fig. 17, thus providing space for a straight instead of a curved railway station, and adding considerably to the area at the disposal of the Harbour Board.

The widening provides for a total increase of about 50,600 sq. yds., or nearly 10·5 acres on the old Admiralty Pier for the requirements of the rapidly increasing Continental traffic of the port.

Widening No. 2 is of less extensive character, and merely involves the addition of a continuous timber landing stage, 12 ft. to 14 ft. wide, along the inner side of the Admiralty Pier extension, commencing from the termination of Widening No. 1, and ending at a distance of about 470 ft. from the seaward end of the extension. This widening will give an additional space of between 2,000 and 2,300 sq. yds., and is intended to provide accommodation for ocean liners, and as the staging will be of sufficient length to permit two of the largest vessels hitherto built to lie alongside simultaneously, the benefit of the improvement is self-evident.

The effect of the two widenings will be to make the total area of the Admiralty Pier and the Admiralty Pier Extension within the limits of the new works about eleven acres, which will constitute a most valuable space for dealing with passenger traffic and one unrivalled in the respect that it will be bordered on either side by deep water, permitting the largest steamers to come alongside at any state of the tide.

We next come to a group of three works intended to give additional quay and wharf space in the Commercial Harbour. Of these works, Quay No. 1 is to be built in the entrance channel to the Tidal Harbour from the north-west corner to the south-west corner of the South Pier, a distance of about 300 ft. Quay No. 2, practically forming a continuation of Quay No. 1, will commence at the south-eastern corner of the South Pier and terminate at a point about 240 ft. distant in a south-easterly direction. The same wharf is to be further continued by Quay No. 3, which will take a south-westerly direction for a distance of about 430 ft. to effect a junction with the commencement of Widening No. 1 near the shore end of the Admiralty Pier.

By the construction of these three quays and the reclamation of the areas behind the walls a site measuring about

eleven acres will be secured for the purposes already mentioned.

A fourth work of similar character is represented by an embankment and quay wall, denoted as Quay No. 4 in Fig. 17, to be built along the south-western end of the existing Tidal Harbour. The length of the proposed quay being 650 ft., and the width of the improvement 50 ft., the additional space gained will be some 3,600 square yards.

In addition to furnishing sites for the erection of transit sheds, warehouses and offices, on the land reclaimed, the execution of the foregoing works will enable the Harbour Board, in co-operation with the railway companies, to arrange for new lines and sidings on an extensive scale, connecting the landing stages and the new commercial quays with the passenger and goods stations of the Chatham and Dover and South Eastern Railway systems. One of the new lines, termed Railway No. 1 in Fig. 17 will commence at a junction with the main line of the Chatham and Dover Railway in the Harbour Station and terminate near the seaward end of Widening No. 1 on the old Admiralty Pier. The clause relating to this line also provides for the construction of a railway station, with sidings, buildings, and all other works necessary or convenient for the conduct of traffic, and for the embarcation and disembarcation of passengers and merchandise.

This a very innocent looking provision, in no way conveying the impression that the new Continental Marine Station is intended to cover more ground than Charing Cross Station, and that among "other works necessary or convenient" will be a new Transatlantic Marine Station of considerable side. Particulars of the new Continental Station, as proposed by the engineer to the Harbour Board, are given later in the present article, but this, in common with all other details of the general scheme, is subject to the approval of "the principal engineer for the time being of the railway company."

The other new line, indicated on the plan as Railway No. 2, is to be commenced at a junction with the main line of the South Eastern Railway in the Town Station and terminating at the same place as Railway No. 1. The clause relating to this line provides for the construction of all necessary stations, sidings, buildings, and other works, and also for works in connection with the closing of certain public thoroughfares.

The thoroughfares in question are those known as Custom House Quay along one side of the Granville Dock, and Beech Street, which borders the landward side of the South Eastern Station. So far as the former thoroughfare is concerned the town of Dover will suffer no loss, and the opinion is freely expressed that it ought to have been reserved for harbour purposes from the first, as the present roadway has long been required for railway lines to provide for goods traffic between the docks and the two railway systems. The case of Beech Street is somewhat different, but its extinction will not cause any practical inconvenience, for the viaduct scheme of the Dover Corporation already involves the disappearance of the street to a considerable extent.

It may here be explained that the viaduct scheme is a project for a broad elevated highway with double tramway lines, leading from the chief business street of the town to the foot of the Admiralty Pier, the viaduct passing at the back of the Chatham and Dover station.

We give in Fig. 18 a plan of the proposed viaduct, which, although forming no part of the Harbour Board's programme, must be looked upon as auxiliary thereto, and as a distinct indication of the manner in which the corporation are participating in the general improvement of the port.

The masonry works involved in the widening of the Admiralty pier, and in the construction of the various wharves, quays, and reclamation works will necessarily be of extensive character. This important part of the scheme will be carried out up to the coping level by Messrs. Coode, Son and Matthews and

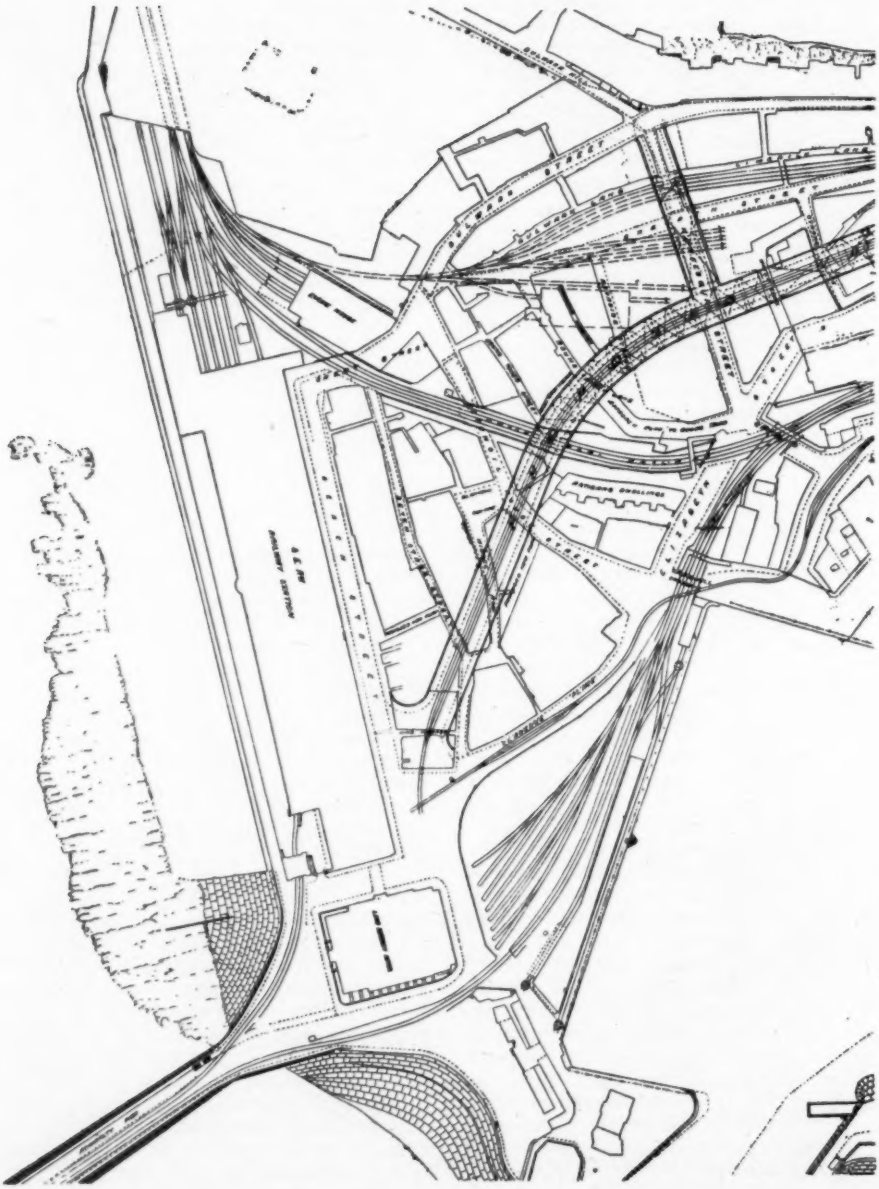
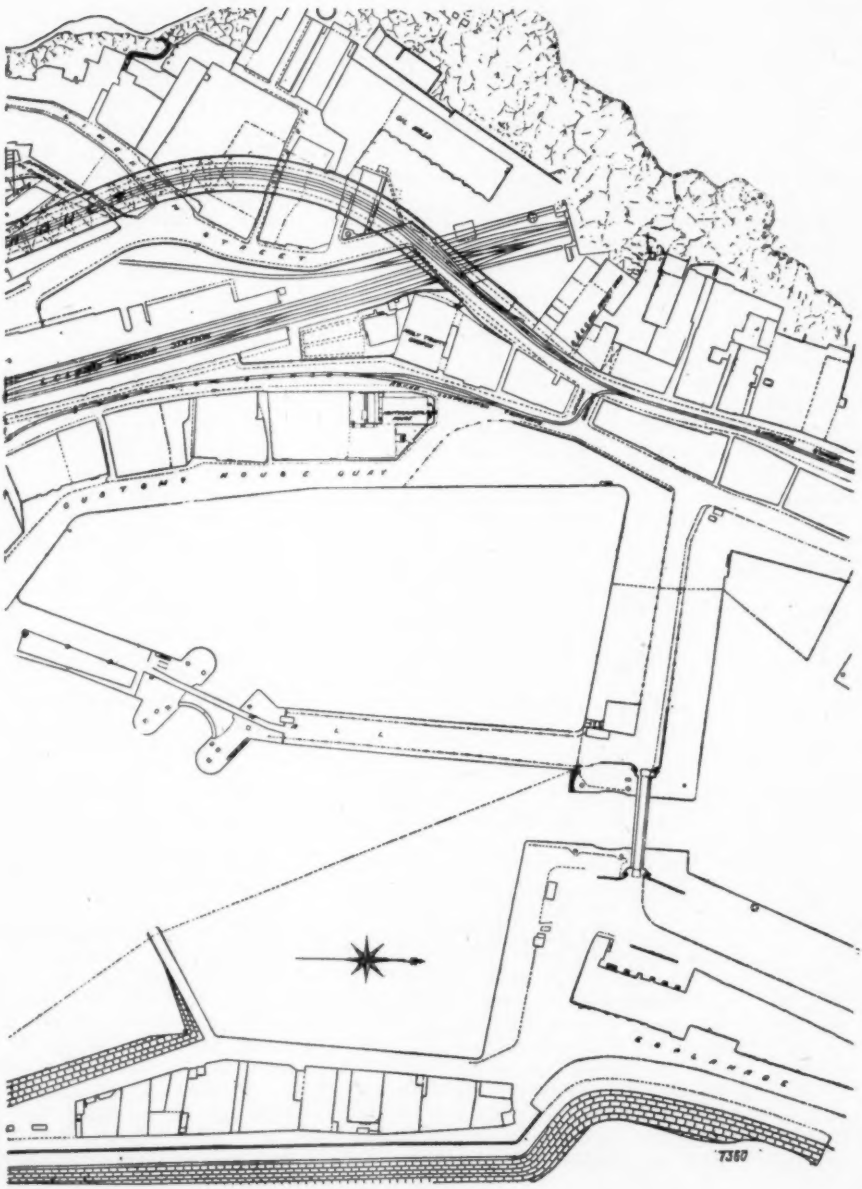


FIG.



18.

the general method of construction will be similar to that followed in the case of the reclamation wall, between the Castle Jetty and the East Pier, described in Article No. 2.*

Above coping level, the works to be executed on the piers and quays will come entirely within the province of the the port authorities, by whom, however, the convenience and wishes of the South Eastern and Chatham Railways will have to be studied in every respect. Although the Bill will authorise the Harbour Board to construct all the intended works, powers are also taken to provide for the execution of certain portions by either the Harbour Board or the railway companies. As the port authorities and the railway companies are in absolute accord, the equipment of the various landing stages, quays, and other structures directly connected with the harbour will be constructed under the direction of the harbour engineer, and the railway stations and lines to the entire approval of the engineer to the South Eastern and Chatham Railways. As provided by the Bill, the new Continental Station may be built either by the South Eastern and Chatham Railways, or by the Harbour Board and leased to the managing committee of the two railway companies.

The Bill provides further that all the intended works shall be vested in the Harbour Board with all such powers and rights as if they had been constructed under the Dover Harbour Act 1891, of which the general scope was indicated in Article No. 1,† and that all of them shall be deemed to be part of Dover Harbour. Messrs. Coode, Son and Matthews will deal with the pier widenings and kindred works in accordance with the requirements of the general plans; Mr. P. C. Tempest, the engineer to the South Eastern and Chatham Railways, will deal with the construction of the new railway lines; Mr. A. T. Walmisley, the engineer to the Harbour Board will deal with the new landing stages, and the equipment of the quays and wharves, and being also a well-known expert in iron and steel construction will undertake, probably in conjunction with Mr. Tempest, the erection of the new Continental Station.

The most striking feature of the new programme is this great railway terminus for the convenience of passengers to and from the Continent. The new Continental Station will undoubtedly be the finest marine passenger station in the world, and will effectually remove all cause for complaint on the score of inefficient accommodation at the port which European nations regard as the watergate of England.

According to the designs prepared by the harbour engineer, for the consideration of the railway companies and the Harbour Board, the station will be 800 ft. long by 200 ft. wide, but the height has been kept down as far as possible, so as to expose a minimum surface to the action of gales. Three platforms are shown in the drawings, one in the centre 60 ft. wide, and one on either side 29 ft. wide each, communication between the three being afforded by movable gangways or bridges. Inside the station building there are six lines of rails, and outside it other lines passing directly to the Admiralty Pier Extension, with which the lines passing through the station are also in communication. Three covered double-tier landing stages are to be built on the east side of the widening for Continental traffic, the under tier providing for landing at low water and being in communication with the central platform of the station by means of subways. It is the intention of the Harbour Board to furnish the most complete and perfect accommodation for passengers in the new station, including ample facilities for speedy Customs examination, spacious and well-appointed waiting and refreshment rooms, and a grand restaurant and grill room.

Figs. 19 and 20 are part longitudinal and transverse sections showing the station roof as suggested by Mr. Walmisley. The structure is proposed

* THE ENGINEERING REVIEW, Vol. xiii., pp. 294—5.
† THE ENGINEERING REVIEW, Vol. xiii., pp. 224—5.

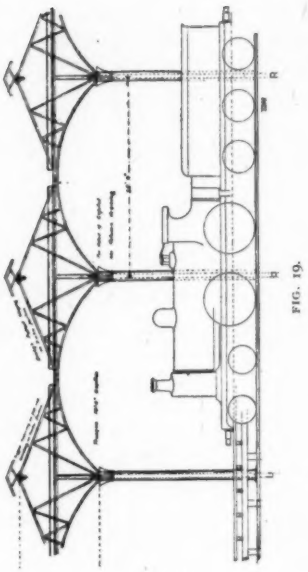


FIG. 19.

to be carried by three longitudinal rows of cast iron columns spaced 26 ft. apart, the rows themselves being 100 ft. apart. The transverse distances of 100 ft. each, from the outer row to the centre row, and from the inner row to the centre row are spanned by lattice girders 10 ft. deep, divided by vertical struts into panels 10 ft. wide, and having a double system of diagonal ties, as illustrated in Fig. 20. Each girder is tapered off at the ends as shown in the same drawing, so that the upper and lower members meet at the capitals of the columns. The spaces between the transverse girders are spanned by double cantilever roof trusses of 25 ft. span spaced 10 ft. apart, and somewhat resembling the cantilevers of the Forth bridge in outline (see Fig. 19). The cantilever arms project 12 ft. 6 in., and at the junction of each pier there is a roof gutter discharging into the longitudinal gutter above the central row of columns. This gutter discharges into vertical extensions of the central row of columns through which water will be conveyed to drain pipes laid below the platform.

The supporting lines of columns can cause no obstruction to traffic for the outer columns are placed outside the 29 ft. platforms and the middle row is in the centre of a wide platform.

Owing to the manner in which the columns are continued up and incorporated into the ironwork of the roof trusses, the design is one that promises maximum strength, solidity and stiffness, and the disposition of the ridges and furrows is such that the least possible resistance will be opposed to the movement of air over the roof surfaces. On the southern side, that most exposed to wind and rain, the roof slopes are covered with sheet copper

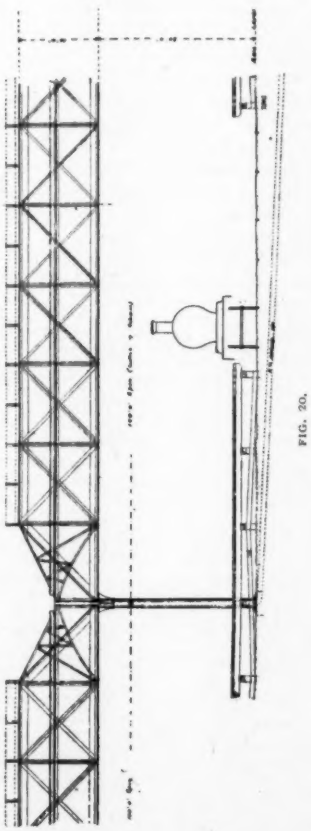


FIG. 20.

laid over felt and boarding; and on the northern side, they are provided with Braby's patent glazing. Thus the roof here proposed provides efficient protection against gales and spray in rough weather, and against the glare of the sun in fine weather, while the ample northern light should insure sufficient illumination in all seasons of the year.

Two points to which attention should be particularly directed are that all the purlins are specified to be of timber, a material selected instead of iron or steel owing to its immunity from deterioration by the steam and fumes emitted from locomotive engines and boilers; and that wrought iron is specified instead of mild steel for the roof principals and other members because of the greater resistance offered to corrosive influences by the former material.

The immunity of timber from injury by exposure to sea air and spray is well known, and the testimony of railway engineers in connection with locomotive depôts proves that timber is preserved rather than destroyed by the empyreumatic products of combustion prevalent in such buildings. The superiority of cast iron and wrought iron over mild steel in point of resistance to corrosion is indicated by the experience of engineers generally, and of marine engineers in particular, the liability of these metals to oxidation being approximately; cast iron 100, wrought iron 129, and mild steel 133.

Reference to Figs. 19 and 20, demonstrates the convenience of the design for the purposes of examination, painting and repair, and as the total height of the roof above rail level is only 30 ft., the public will not be exposed to the risks inseparable from roof principals mounted at a great elevation as in the case of many station buildings in the metropolis and elsewhere. In some respects, the roof design here adopted is on the principle first employed by Mr. Jacomb Hood in the Victoria terminus of the London Brighton and South Coast Railway, where continuous girders, extending from side to side of the station, supported small roof trusses of the queen-rod type. Mr. Walmisley's girders are not continuous but the function of these members is similar to that performed at Victoria station. The adaptation of the cantilever principle for the roof trusses at Dover is a distinctly meritorious feature, and taken in conjunction with the close spacing of the trusses, and the fact that the whole covering is sandwiched within a minimum vertical depth of construction, provides in a most satisfactory manner for the permanent safety of the roof. It is obvious that the stability of the cantilever spans does not depend upon any single member such as the tie rod in an ordinary roof truss, and even if any one member of a cantilever should suddenly fall, the consequences would be quite insignificant and purely local.

(To be concluded.)

The Graphical Conversion of the $P\ V$ into the $\theta\phi$ Diagram.

By WILLIAM J. GOUDIE, B.Sc., A.M.I.Mech.E.

In the case of an engine using saturated steam, the $P\ V$ diagram can be converted into the $\theta\phi$ equivalent, either by a method which is calculative or by one which is, for the most part, graphical in character.

The calculative method, which entails a good deal of diagram scaling and plotting on the chart, is rather tedious, while the graphical method most commonly used, and due to Professor Boulvin, requires the preliminary replotting of the diagrams to to the pressure and volume scales of the chart, before the graphical transference can be carried out. From the time and labour saving standpoint a direct transference from the actual indicator diagrams is desirable; and for the accomplishment of this end the writer has devised a modification of the Boulvin construction, which, it is hoped, may prove useful to those engineers who make frequent use of the temperature-entropy chart. By its adoption the calculative work is reduced to a minimum, the actual indicator diagrams are used directly on the chart, while the replacement of the four-quadrant arrangement by a single diagram enables much larger and more reliable $\theta\phi$ diagrams to be obtained. As the essential principles of the calculative method and the Boulvin method have been graphically embodied in this combination, a brief discussion of these principles is necessary, in order that the combination and the method of constructing it may be clearly understood.

The ordinary form of the temperature-entropy chart on which the calculated $\theta\phi$ values are plotted is shown in skeleton at Fig. 1. It has, in addition to the water curve ($W\ W$) and the saturation curve ($S\ S$), a series of constant pressure lines and constant volume curves. The pressure lines are horizontals drawn across the chart at different temperature levels and marked with the pressure values corresponding to these temperatures. The constant volume curves are curves of equal specific volume for steam of varying dryness, and can be located on the chart by dividing the horizontal intercepts between the ($W\ W$) and ($S\ S$) curves, at several pressure levels, into as many parts as there are cubic feet per pound of dry saturated steam at each pressure, and then joining the correspondingly numbered points on the pressure horizontals. This division of the intercepts can be expeditiously carried out by the proportional method illustrated at the 100 pressure-horizontal. One pound of dry saturated steam at 100 lbs. per sq. in. occupies 4·33 cub. ft. The line $E\ L$ is drawn at any convenient angle to $E\ G$, and the distance $E\ L = 4{\cdot}33$ ins. is scaled off. Parallels to $L\ G$ through the 1, 2, 3, &c. divisions on $E\ L$ give the corresponding points on $E\ G$. The dryness fraction of the steam at any given pressure is the ratio of the intercept between ($W\ W$) and the volume curve for one pound of the wet steam, and the intercept between the ($W\ W$) and ($S\ S$) curves, so that if the dryness fraction is known, the volume occupied by one pound of wet steam can at once be ascertained by noting the constant volume curve which divides the pressure horizontal in this proportion. Thus, suppose that one pound of H_2O stuff initially in the condition of dry saturated steam at 180 lbs. per sq. in. is admitted to a vessel having a capacity of 2·5 cub. ft., and that immediately after admission 20 per cent. of the pound of steam is condensed back to the liquid condition. The steam will forthwith expand and fill the volume of the vessel, less the very small volume occupied by the water of condensation (which is negligible for all practical purposes), and the pressure will consequently fall. The volume of steam in the vessel may still be taken as 2·5 cub. ft., and as this represents ·8 lbs of dry saturated steam at the lower pressure, the specific volume of the dry steam at this pressure will be $\frac{2{\cdot}5}{{\cdot}8} = 3{\cdot}125$ cub. ft.; this, in the steam tables, corresponds to a pressure of 140 lbs. per sq. in.

Hence, in this vessel, a weight of one pound of wet steam at 140 lbs. per sq. in. and having a dryness fraction of ·8, occupies 2·5 cub. ft.; and if the "state point" B is located on the intercept between ($W\ W$) and ($S\ S$), at the 140 pressure-horizontal, distant ·8 of

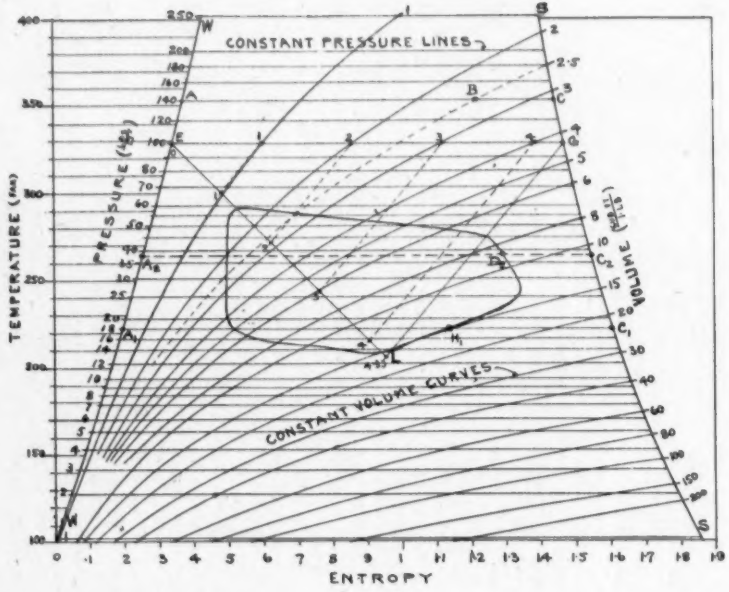


FIG. 1.

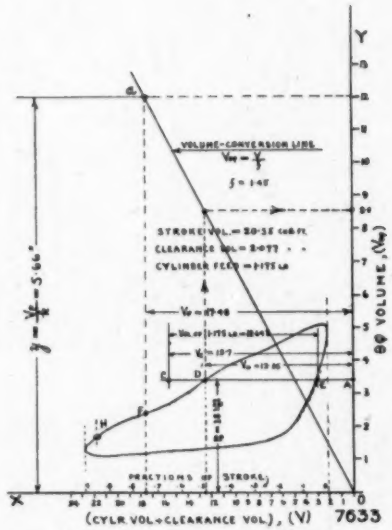


FIG. 2.

the length of the intercept from (W W) (viz., $A\,B = \cdot 8\,A\,C$), it will fall on the 2·5 constant volume curve. Now this vessel may be taken to represent the cylinder of an engine, and the volume occupied by the H_2O stuff as that of the (cylinder volume + clearance volume) behind the piston at any point of the stroke.

In an actual engine, however, the weight of H_2O stuff contained in the cylinder during the expansion period is always more or less than one pound, say w pounds, so that the (cylinder volume + clearance volume) is the volume per w pounds of H_2O stuff, while the volume ascertained on the chart by locating any such state point as B is the volume per pound. This chart volume therefore represents the value of the (cylinder volume + clearance volume) divided by the weight of H_2O stuff w, and it may be termed the $\theta\phi$ volume. Denoting it by the general symbol $V\theta\phi$, and the (cylinder volume + clearance volume) by V, the foregoing condition is expressed by the equation $V\theta\phi = \frac{V}{w}$, or writing it in the other form, $\frac{V}{V\theta\phi} = w$. The weight w is, however, constant only during the expansion period,

and the $V\theta\phi$ value, obtained for any point of the cycle between release and cut off, does not enable any conclusion to be drawn regarding the condition of the steam in the cylinder at that point.

Thus, on the $\theta\phi$ diagram (Fig. 1), which is the equivalent of the *P V* diagram (Fig. 2), the point D_2 corresponds to the point *D* on the expansion curve, and $\frac{A_2D_2}{A_2C_2}$ gives the dryness fraction of the steam at this point, that is, the proportion of each pound of H_2O stuff present in the cylinder which is in the condition of dry saturated steam. On the other hand H_1, which corresponds to a point *H* near the "toe" of the *P V* diagram, after release has taken place, merely indicates that at that point the equivalent volume per pound of the original weight of stuff in the cylinder, some of which has been discharged to the condenser, is 15 cub. ft.; and the ratio $\frac{A_1H_1}{A_1C_1}$ gives no indication of the "quality" of the steam in the cylinder. This equation in fact is only valid for the complete cycle on the assumption that the *P V* diagram lines are "replaced by imaginary reversible operations forming a closed cycle, and giving the same area of work." This assumption of the *P V* diagram as the diagram of external work of a closed cycle, enables a check to be made on the accuracy of the transference, as the heat value of the $\theta\phi$ area must equal the heat equivalent of the *P V* area per pound of stuff. With reference then to the whole cycle represented by the *P V* diagram, the quotient $V\theta\phi$ represents merely a factor of volume correction, and hence it is termed the "volume-factor."

Denoting it by the general symbol *f*, the expression for the determination of the $\theta\phi$ volume at any point on the *P V* diagram becomes, $V\theta\phi = \frac{V}{f}$ .....(1). To transfer the diagram by the ordinary method, the mean indicator card is scaled at a number of points (say twenty), the pressures for the forward and backward strokes and the corresponding (cylinder volume + clearance volume) values are tabulated and the $\theta\phi$ volumes calculated by equation (1). The points are then located on the chart at the intersections of the pressure horizontals and the constant volume curves.

If the numerical example just given is worked backward, it will be apparent that when the dryness fraction for any point on the expansion curve of an indicator diagram has been ascertained, the $\theta\phi$ volume can be calculated directly, that is, without any reference to the chart curves, by simply multiplying the (volume per pound of dry saturated steam) at the given pressure, by the dryness fraction.

Referring to Fig. 2, let *O X* be the (cylinder volume + clearance volume) or *V* axis, and *O Y* the $\theta\phi$ volume or $V\theta\phi$ axis, then equation (1) will give a straight line *O a* passing through the origin *O*; and if the actual indicator diagram is placed in the co-ordinate field with its line of zero volume coincident with *O Y*, and line of zero pressure coincident with *O X*, it is evident that, for any point *D*, the $V\theta\phi_D$ corresponding to V_D can at once be obtained by simple projection vertically from *D* to *O a*, then horizontally from *O a* to *O Y*.

In the case illustrated, $V_D = 12{\cdot}35$ cub. ft., the graphically determined $\theta\phi$ volume corresponding to 1·45 lbs. H_2O stuff is $V\theta\phi_D = 8{\cdot}5$, and the state point D_2 (Fig. 1) falls on the 1·38 pressure horizontal at the 8·5 constant volume curve.

It is this graphical interpretation of the essential feature of the calculative method, that the writer has applied to a modified arrangement of the Boulvin chart.

For the determination of *f*, the dryness fraction should be calculated at some point *D* (Fig. 2), after cut-off has taken place, by continuing the compression curve to cut the horizontal through *D* in *E*, setting off *E C* equal to the volume which would be occupied by the "cylinder seed" if it existed in the cylinder as dry saturated steam at pressure P_D, then dividing the length *A D* by *A C*. In this case the amount of H_2O stuff which passed through the cylinder per stroke (as measured from the air-pump discharge) was 1·175 lb. Its volume, as dry saturated steam, would have been 12·643 cub. ft. at 38 lb. per sq. in., and the actual volume expanding in the cylinder at this pressure approximately 15·7 cubic ft. instead of 12·35 cub. ft. Hence $\frac{A\ D}{A\ C} = \frac{12{\cdot}35}{15{\cdot}7} = {\cdot}79 =$ dryness fraction *x*.

Then, *x* (specific volume of dry saturated steam at 38 lbs. per sq. in.) is $V\theta\phi_D = {\cdot}79 \times 10{\cdot}76 = 8{\cdot}5$ cub. ft., so that $f = \frac{V_D}{V\theta\phi_D} = \frac{12{\cdot}35}{8{\cdot}5} = 1{\cdot}45$.

Turning next to the Boulvin method, the complete chart is shown in skeleton at Fig. 3.

The pressure temperature (*P T*) curve is plotted in the first quadrant from the values given in the steam tables, *O X* being the pressure axis and *O Y* the temperature

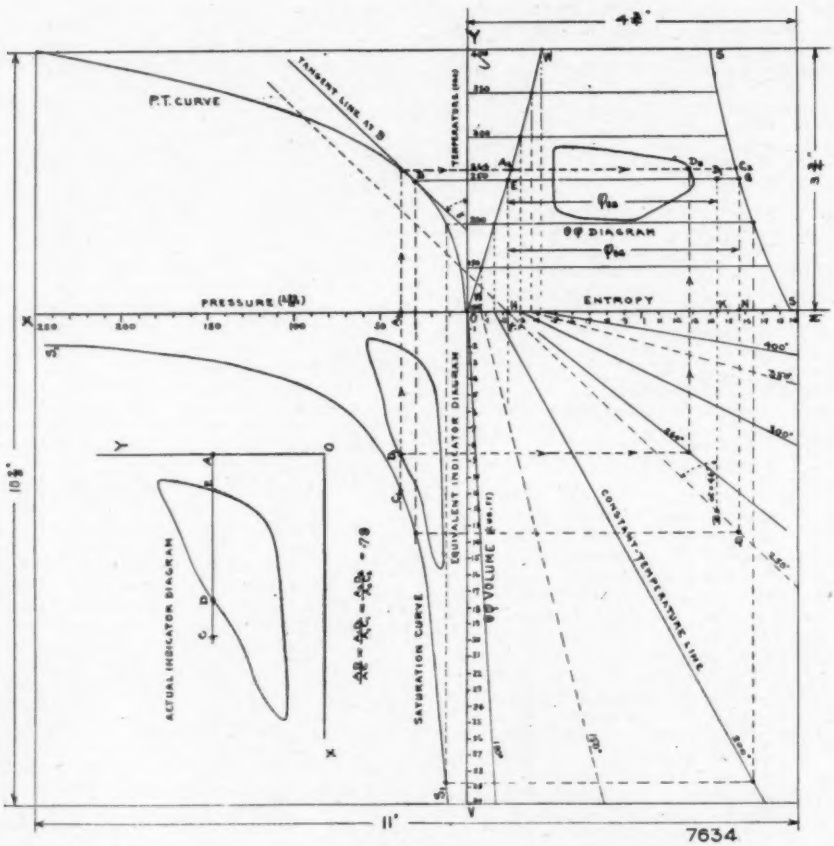


FIG 3.

axis. The (W W) and (S S) curves of the $\theta\phi$ chart proper are plotted in the second quadrant, O Z being the entropy axis. At any point B on the P T curve, it can easily be shown that the rate of increase of pressure with temperature

$$\frac{d\,P}{d\,T} = \frac{J\,\phi_{SB}}{(v-u)\,x}, \text{ where}$$

J = Joule's equivalent.
ϕ_{SB} = Entropy of the wet steam at pressure P_B and temp. T_B.
v = Volume per lb. of steam in the dry saturated condition.
u = Volume of 1 lb. of water.
x = Dryness fraction = $\frac{E\,B_1}{E\,G}$.

Here $\frac{d\,P}{d\,T}$ is the tangent of the angle α, which a tangent line at B makes with the temperature axis O Y, so that tan. $\alpha = \frac{J\,\phi_{SB}}{(v-u)\,x}$. If E H, B K M and G N Q are drawn perpendicular to O Z, and if H M Q is drawn, in the third quadrant, parallel to the tangent line, then the angle $H\,M\,K = \alpha$, and $\frac{H\,K}{M\,K} = \text{tan. } \alpha$. Hence, $\frac{\phi_{SB}}{M\,K} = \frac{J\,\phi_{SB}}{(v-u)\,x}$, and $M\,K = \frac{(v-u)\,x}{J}$. The volume of 1 lb. of water is so small in comparison with v that for practical purposes it is negligible, so that the result may be written, $M\,K =$

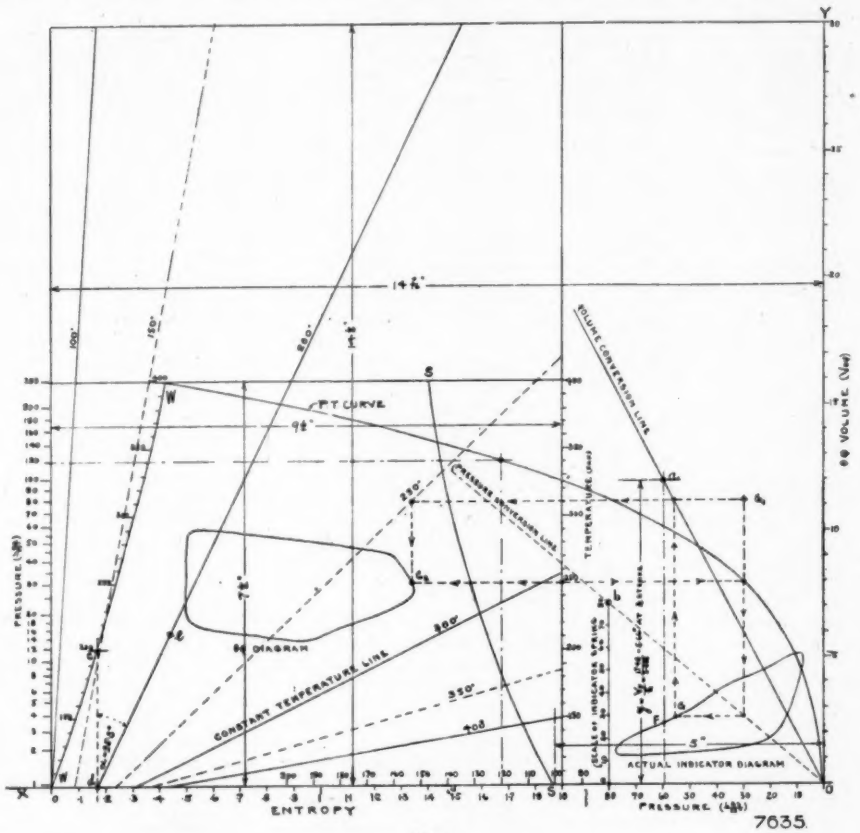


FIG 4

$\frac{v\,x}{J} = \frac{V\theta\phi}{J}$. Joule's equivalent is a constant, so that the vertical intercept $M\,K$, between $H\,M\,Q$ and the axis $O\,Z$, is proportional to the specific volume of the wet steam; and this length may be taken to represent that volume on some comparative scale. If the dryness fraction x is unity, then $N\,Q$ will similarly represent the specific volume of dry saturated steam on the same comparative scale. The point B on the $P\,T$ curve has been chosen at 30 lb. per. sq. in. pressure and 250° F.; the specific volume of dry saturated steam from the tables is 13·5 cub. ft., so that by dividing $N\,Q$ into 13·5 parts, the unit length of the $V\theta\phi$ scale can be ascertained. When this scale is set off from $O\,Z$ along $O\,V$ the θφ volume of the steam at any pressure and temperature, and in any condition of dryness denoted by the horizontal location of the state point in the second quadrant, can at once be ascertained by simple projection vertically to $H\,M\,Q$, and horizontally to $O\,V$. Conversely when the $V\theta\phi$ is known, the state point can be quickly located by a reversal of this operation.

$H\,M\,Q$ is called a "constant temperature" line. If these constant temperature lines are drawn for, say, every ten degrees, and perpendiculars are let fall on them from the ($S\,S$) curve, the horizontal projectors, when carried into the fourth quadrant, intersect the corresponding pressure verticals on a $P\,V$ saturation curve ($S_1 S_1$), as illustrated at the 200° and 250° temperature values.

With this arrangement the graphical location of any "state point" D_2 corresponding to a point D on the actual indicator diagram, cannot be carried out until an intermediate point D_1 has been located on the P_D pressure vertical under the saturation curve (S_1S_1), so that $\frac{A_1D_1}{A_1C_1} = \frac{A\ D}{A\ C}$. In other words the equivalent indicator diagram for a cylinder, in which the weight of working fluid is one pound, has first to be replotted in the fourth quadrant. This then forms the basis for the graphical transference which is indicated, for the point D, by the dotted projection lines and arrow heads. The indicator diagram used is that shown at Fig. 2. Now while this arrangement is conducive to a clear understanding of the underlying principle, the writer fails to see any particular reason for an adherence to it when the principle has to be put to practical use. The first quadrant may be chosen for the $P\ V$ co-ordinate field as well as the $P\ T$ one, $O\ Y$ representing the temperature and volume axis.

The constant temperature lines fall in the second quadrant just as the constant volume curves do on the ordinary chart, and the combination is reduced to half the original size. The process of contraction can, however, be carried still further if the origin is transferred to the right of the ($S\ S$) curve as shown at Fig. 4. By adopting this condensed arrangement it is evident that a much larger and more reliable $\theta\phi$ chart proper can be obtained.

As already shown, by the introduction of the volume conversion curve $O\ a$ (Fig. 2), the $\theta\phi$ volumes can be quickly located from points on the actual indicator diagram; and if a second conversion line $O\ b$ (Fig. 4), is introduced, to convert pressure values on the scale of the indicator spring to the corresponding values on the pressure scale of the chart, a purely graphical method of locating the points on the equivalent indicator diagram is evolved. Take for example the point G, where the pressure is P_G. By projecting horizontally to $O\ b$ the P_G pressure vertical is at once located; by projecting vertically to $O\ a$ the $\theta\phi$ horizontal is located, and the point G_1, on the equivalent indicator diagram will lie at their point of intersection. There is obviously no necessity to consider the location of any such point G_1, in the co-ordinate field, as the projectors which pass through it can be carried direct from the $O\ b$ and $O\ a$ lines to the $P\ T$ curve and constant temperature curve, and a replotted diagram is therefore superfluous.

When this combination is put to practical use the operation of transference should be commenced, not from a point on the diagram, but from some temperature value, for which there is a corresponding constant temperature line, as illustrated at the 250° Fahr. value, for which G is the corresponding point on the diagram. As in the previous case, the dotted projection lines and arrow heads show the direction and sequence of the steps of the conversion. The pressure conversion curve is obtained by setting up, at any pressure vertical, the corresponding pressure value on the scale of the indicator spring, and drawing a line from the point obtained to the origin. The illustration at the 80 lbs. per sq. in. value will make this clear.

With regard to dimensions, the temperature, entropy and pressure scales are quite arbitrary. The following scales seem to be most suitable, as the resulting dimensions of the chart are such that all the diagrams of a triple expansion engine, with L P cylinder capacity from 50 to 70 cub. ft., can usually be transformed with fair accuracy within the limits of an imperial sheet of paper. On the chart shown at Fig. 4, the entropy scale has been taken as 5 in. $= \frac{1\ \text{B.T.U.}}{1°\ \text{F.}}$ (entropy unit), and the temperature scale 1 in. = 40° Fahr. When the scales have been set off along their respective axis the ($W\ W$) and ($S\ S$) curves can be plotted from the entropy values for water, ϕ_w, and (water and steam) ϕ_{w+s}, given in columns 2 and 4 of Table I. (*see below*). The constant temperature lines should be drawn in next, and it will be

TABLE I.

1	2	3	4
Temp. Fah	ϕ_w	ϕ_s	ϕ_{w+s}
100	0	1·865	1·865
150	·0859	1·654	1·740
200	·1663	1·476	1·642
250	·2394	1·322	1·561
300	·3089	1·188	1·497
350	·3746	1·069	1·443
400	·4369	·965	1·402

quite sufficient to draw these for ten-degree intervals of temperature. It should be noted that, in Fig. 3, the slope of the $P\ T$ curve at any point will depend on the relative dimensions of the pressure and temperature scales. For instance if the tangent value $\frac{d\ P}{d\ T}$ or $\frac{\text{increment of pressure}}{\text{increment of 1° F.}}$

has a certain value when the same length which represents 1° F. also represents 1 lb. per sq. in., it will be doubled if the dimension of the pressure scale is doubled, as the little length representing the same increment of pressure $d\ P$ will also be doubled, and $\tan.\ \alpha\ 2 = \frac{d\ P}{d\ T}$. The same holds for any other multiple, so that, generally, if the (pressure unit-length) = (n × temperature unit-length), then $\tan.\ \alpha = n\ \frac{d\ P}{d\ T}$, where $\frac{d\ P}{d\ T}$ is the value ascertained for scales of equal dimension, or where $n = 1$. In this case the value of $n = 2$ has been chosen, and the pressure values have been set off from O (distant about 5 in. from S) along $O\ X$, to the scale of 1 in. = 20 lbs. per sq. in. Values of $\frac{d\ P}{d\ T}$, obtained from the appendix to Prof. Cotterill's text on the steam engine, are given in column 2, the tangent values or $2\ \frac{d\ P}{d\ T}$ in column 3, and the corresponding values of α in column 4 of Table II. (*see below*). To draw the constant temperature line for

TABLE II.

1	2	3	4
Temp. Fah.	$\frac{d\ P}{d\ T}$	Tan. $\alpha = 2\frac{d\ P}{d\ T}$	$\alpha°$
100	·0283	·0566	3°2
110	·0367	·0734	4°2
120	·0469	·0938	5°33
130	·0594	·1188	6°8
140	·0743	·1486	8°45
150	·0918	·1836	10°4
160	·1133	·2266	12°7
170	·1375	·2750	15°3
180	·1665	·333	18°4
190	·2005	·401	21°8
200	·2385	·477	25°5
210	·2825	·565	29°46
220	·3325	·665	33°6
230	·3910	·782	38°03
240	·455	·91	42°3
250	·523	1·046	46
260	·603	1·206	50°3
270	·691	1·382	54
280	·785	1·570	57°5
290	·892	1·784	60°7
300	1·012	2·024	63·7
310	1·135	2·27	66°2
320	1·275	2·55	68°6
330	1·42	2·84	70°6
340	1·58	3·16	72°4
350	1·75	3·5	74°1
360	1·94	3·98	75°9
370	2·14	4·28	76°9
380	2·35	4·7	78
390	2·57	5·14	79
400	2·805	5·61	79·9

any given value, say 200° F., drop from c, the point of intersection of the 200° F. horizontal and the ($W\ W$) curve, a perpendicular $c\ d$ to the entropy axis, and carry it well below this line. Place the base line of a large circular protractor on this perpendicular, with the mid point at d, and mark the point e at $\alpha = 25{\cdot}5°$, then draw $d\ e$. This construction must be carefully done as any slight error in the slope of a line, especially at the lower temperature values, will tend to give erroneous results in the case of an L P diagram.

The vertical scale of pressures should now be set off from the values given in the steam tables, and after this has been done the points on the $P\ V$ curve can be located at the intersections of the corresponding pressure horizontals and verticals, as illustrated at the 120 pressure values.

There still remains the derived scale of $\theta\phi$ volumes. Its dimensions should be ascertained by calculation rather than by construction. It may be arrived at as follows: Let the entropy scale be l in. = 1 entropy unit, then for dry saturated steam with entropy ϕ_{SG} (Fig. 3) it follows that $H\ N = l\ \phi_{SG}$ in. If $N\ Q$ = specific volume of dry saturated steam = v cub. ft. then, $\tan.\ \alpha = \frac{H\ N}{N\ Q} = \frac{l\ \phi_{SG}\text{ in.}}{v\text{ cub. ft.}}$, so that substituting $n\ \frac{d\ P}{d\ T}$ for $\tan.\ \alpha$,

$$1\text{ in.} = \frac{v\ n\ \frac{d\ P}{d\ T}}{l\phi_{SG}}\text{ cub. ft.} \ldots\ldots (2).$$

Numerical values at different temperatures should be substituted in equation (2), and the average of the results adopted as the scale. This average, when $n = 2$ and $l = 5$ in., is 1 in. = 2·13 cub. ft.

It is this scale which has been set off along $O\ Y$ (Fig. 4), and it can be used for the location of the volume conversion curve Oa from equation (1), when the actual (mean) indicator diagram has been placed in the $P\ V$ co-ordinate field, and the value of V at any point of the stroke has been ascertained.

If, however, this scale value be expressed in general terms, thus 1 in. = C cub. ft., then obviously $\frac{V\theta\phi}{C} = y$ in., or $V\theta\phi = C\ y$ in. Substituting this value in equation (1), $C\ y$ in. $= \frac{V}{f}$, or $y = \frac{V}{C\ f} = \frac{V}{k}$ in. ..... (3). Hence by multiplying the $V\theta\phi$ scale coefficient and the volume factor an ordinate factor k is obtained, and the linear value of for y any point such as "a" on the volume conversion curve, corresponding to the cylinder volume V, can be obtained by means of equation (3) without reference to the $\theta\phi$ volume scale at all. In this case, at $\frac{3}{4}$ stroke, V =

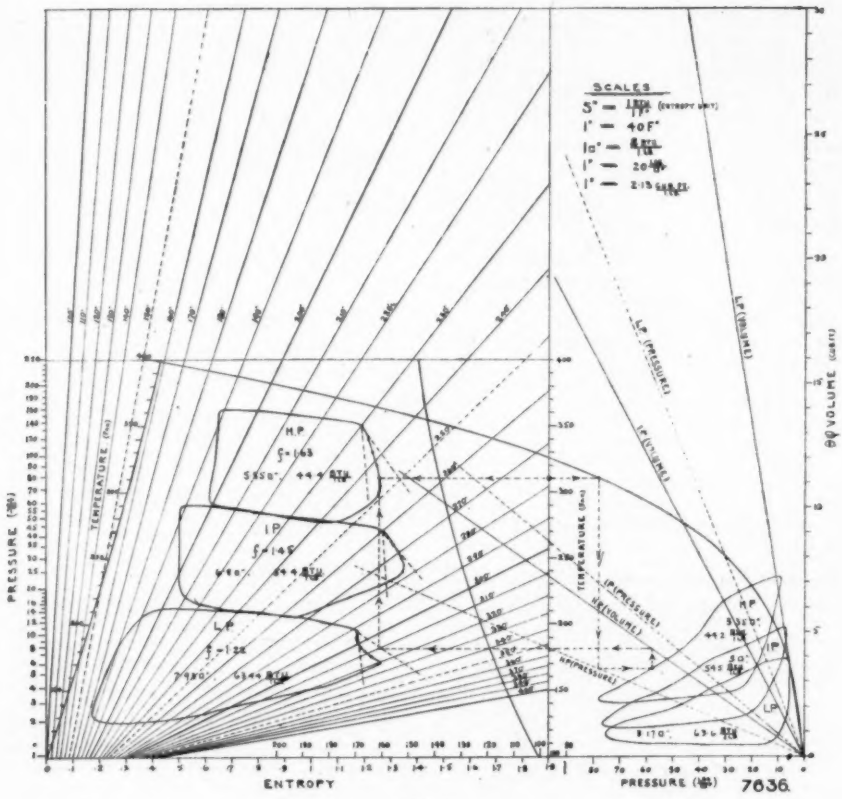


FIG. 5.

17·48 cub. ft., $k = 2·13 \times 1·45 = 3·088$, hence $y = \frac{V}{k} = \frac{17·48}{3·088} = 5·66$ in. Although one point is sufficient for the location of the line *O a*, it is advisable, in order to secure accuracy of slope, to plot points at say full, three-quarter, half and quarter stroke. In Fig. 4 the $\phi\phi$ scale has been carried to the same value on *O Y* as the scale on *O V* (Fig. 3). The overall dimensions are for Fig. 4, $14\frac{7}{16}$ in. × $14\frac{1}{2}$ in. and for Fig. 3, 11 in. × $10\frac{1}{4}$ in. The corresponding dimensions of the $\phi\phi$ charts proper are, for Fig. 4 $9\frac{1}{2}$ in. × $7\frac{1}{2}$ in., and for Fig. 3, $4\frac{3}{4}$ in. × $3\frac{3}{4}$ in., so that a thirty per cent. increase in overall dimensions gives one hundred per cent. increase in the dimensions of the $\phi\phi$ chart proper, in the case of the modified combination.

The combination, complete in all its details, is shown at Fig. 5. It can be easily and quickly traced and any number of black and white photo-print reproductions can then be taken.

When used for the diagrams of a large L. P. cylinder, the print should be pinned down on the board with a large sheet of paper below it, as it will usually be found that the L. P. conversion curve and one or two of the temperature lines have to be extended beyond the upper limit of the print, in order to get the exact location of the points in the $\phi\phi$ diagram near release.

To show the full application of this method of transference, diagrams from the engines of the ss. *Iona*, one of the six steamers whose engines were tested by the Inst. Mech. E. Research Committee on

Marine Engine Trials, have been transformed on the chart (Fig. 5). They have been chosen purposely, in order that the results obtained here, graphically, can be compared with the original plotted $\theta\phi$ diagrams given in the proceedings for 1894 on Plate 16. The *P V* diagrams shown on the chart are the means of the top and bottom diagrams given in the proceedings for 1891 on Plate 46. The intermediate diagram will be recognised as the one which has been used to illustrate the methods of construction at Figs. 2, 3, and 4.

Full particulars of the trial and all the necessary data and discussion thereon will be found in the proceedings mentioned above, and there is therefore no occasion for any further comment on these diagrams.

The "Granton" 40 H.-P. Omnibus Chassis.

THE Scottish Motor Engineering Company, Ltd., have just completed the first of a large number of Omnibus Chassis of entirely new and novel construction, in which there are several points well worth the notice of all interested in this type of vehicle.

The engine is of the usual vertical type, having four cylinders, 5 in. bore and 6½ in. stroke, the cylinders being cast separately. The water jackets are exceptionally large, which is of great importance considering the exceptional work which a vehicle of this description is put to, and more especially so over the cylinder heads.

Sparking plugs are fitted on both sides of the cylinders, and two systems of ignition are fitted, one being the synchronised and the other the ordinary high tension four trembler system. The inlet and exhaust valves are mechanically operated and fitted on either side of the cylinders, having ports of very large area. A special form of governor is fitted to give an absolute cut-out instead of throttle, as usually employed, which ensures a steady running engine and a saving in fuel consumption. When each cylinder is cut out cold air only is drawn in through a relief valve, which keeps the cylinders cool.

The carburettor is of very simple design, and fitted with water jacket, which ensures a better vaporisation.

The whole engine is of very strong and substantial design throughout, having exceptionally long bearings to the crank and cam shafts. Forced feed lubrication is provided to all the working parts.

The radiator, of special design and fitted with a fan, is of large capacity, and greatly exceeds any used on this class of vehicle. Hitherto this has been a source of serious trouble, owing to the slow speed of the vehicle in the first instance, and so many stoppages and slow crawling in heavy traffic, and is almost of double the capacity required in the ordinary way for this power of engine. The water s circulated by geared pump of large capacity, and is placed above the engine frame and in a position that is easily got at for gland packing, &c.

The transmission is also another important feature, the power being transmitted through a specially designed irreversible coil shockless clutch to the speed gear. The speed gear is of the Epicyclic type, having three speeds forward and reverse, the top speed being a direct drive. The power is thence transmitted through a universal jointed shaft on to the differential gear through very large and substantial machine-cut bevel wheels, and thence by chains to the road wheels.

Two independent sets of brakes are provided, one internal on the road wheels, and the other external on the two sprocket pinion drums, both the brakes being compensated by differential gear, and will act in either direction. This is also a novel feature in heavy vehicle construction. Compensation is also arranged for when adjusting the chains, and all adjustments are easily got at.

A large petrol tank of 30 gallons is provided under the driver's seat, and feeds the carburettor by gravity.

One very notable feature in this car is the absence of complicated levers near the driver's seat. The only levers that the driver has to work when driving are the speed lever and the usual foot and hand brake levers, the object being to simplify the work of the driver and at the same time to make the car as fool-proof as possible.

The whole of the working parts of the car generally are of very substantial design, in view of the extraordinary and heavy work expected of this class of vehicle.

This car has been designed and manufactured entirely at the Company's Works at Granton Harbour, and is of British construction and material throughout.

Results of Recent Experience in the Bacterial Treatment of Sewage.

By W. H. MAXWELL, A.M.Inst.C.E.

(Continued from Page 417, Vol. 14.)

Suspended Matters in Effluents.—The matters in suspension in effluents from percolating beds require careful attention, and, as already pointed out, must be effectually removed before the effluent can be discharged. The suspended matter carried away in the effluent from the "Leeds" filter (dealing with crude sewage), amounted to as much as 27 parts per 100,000, and was therefore subjected to an alternative treatment of settlement and filtration. The settlement was effected by a twelve-hour flow through a settling tank to remove the heavier solids, and the filtration consisted of passing the effluent through a 6 in. layer of very fine clinker at the rate of 400 gallons per square yard per day. When this fine filter is in its best condition, that is after the first slight surface clogging, the effluent therefrom is clear and sparkling, and as clear as drinking water.*

With most trickling beds this necessity for settlement or filtration of the effluent has to be taken into account and provided for. The subject was referred to by Dr. Gilbert J. Fowler, in his Manchester lecture, in the following instructive manner. He observes that—

"It very frequently happens, especially in the case of continuous filters, that considerable quantities of suspended matters pass away in the effluents. It may also be that the effluent when incubated along with these suspended matters, is not putrefactive. It must not, however, always be concluded that the suspended matter is harmless, as, if allowed to settle, the clear filtrate poured off, and the suspended matter separately incubated with distilled water, then it will often be found putrefactive, The character of suspended matter, which separates from filtrates under various conditions, requires careful study. Perfectly clear land filtrates may, on standing, give ferruginous deposits, partly due to oxidation of iron present originally as organic ferrous salts, and partly due to the presence of bacteria which collect and separate iron from solution, *e.g.*, crenothrix. The same may take place in the effluent from contact beds, especially where the sewage contains iron pickling refuse in solution. In the case of open continuous filters, actual suspended matter from the septic tank may find its way in an unoxidised condition through the filters. In all these cases the organic and volatile matter may also be in large degree due to growths of organisms of one kind and another, sometimes, it may be, of a fairly high order, *e.g.*, infusoria, &c. In general it may be said that the more perfect the action of the bed the more harmless or more thoroughly oxidised will the suspended matter be, until finally it may be rightly described as organic residuum or debris. It must, however, if present in more than traces (three grains per gallon have been suggested as a limit), be removed from the effluent by straining or settlement."

Under actual working conditions, it will be found that, should the sprinkler cease to rotate, the increased quantity of sewage passing downwards through the bed at one point speedily results in a turbid effluent and a largely increased quantity of suspended solids. The washing out of accumulations from within the bed also takes place at times of storm, when the rate of flow may increase from a normal of 200 gallons per square yard up to say 1,200 gallons. This is important as a means of clearing the bed from clogging material, but emphasises the necessity of further treatment of the effluent prior to final discharge.

Renewal of Materials in Beds.—The necessity for cleansing and renewal of the material of both contact and percolating beds depends very much upon the construction of the beds and the mode of working them. Provided the materials are well screened and graded, and the beds well aërated and adequately underdrained, the necessity for washing or renewal of the material appears to be very remote, provided, of course, septic tank effluent is dealt with, and that the beds are not overworked.

Growths on Surface of Beds.—Overworking has the effect of largely increasing the growth of the pilobolus on the surface of the bed, which, when excessive, tends to pool the sewage. The amount of this growth depends very much upon the strength of the sewage treated, and intermittance in the spraying of the sewage tends to inhibit its

* Royal Commission on Sewage Disposal. (Third Report, 1903); Question No. 15,043.

development. At Leeds it was found that the growth increased rapidly towards the beginning of spring, when the temperature and condition of the sewage was most favourable. At that time the surface of the filter must be continually forked to keep it clear, but when that period is passed there is less difficulty during the rest of the year.

General Comparison.—On the whole, therefore, from what has been experienced in the working of the two systems, contact and continuous, it is clear that on the various points which have been already referred to, the continuous methods of treatment, whatever may be their merits in other respects, involve much more attention than do contact beds. Maintenance expenses are also likely to be greater, inasmuch as wear and tear on expensive distributors and other mechanical gear, coupled with possible damage or derangement by frost, must be added to the annual charges when investigating questions of comparative cost.

Bacteriological Condition of Effluents from Land and from Bacteria Beds.—In the course of the investigation of the present Royal Commission on Sewage Disposal, attention has been directed to the important questions of the bacteriological purity of effluents from sewage farms and bacteria beds, and also to the necessity and practicability of purification of storm water.

In the past the results yielded by chemical analysis of sewage effluents and of drinking waters have been almost exclusively relied upon in the formation of an opinion as to whether these liquids came within what may be considered as "safe limits," but of recent years great strides have been made in bacteriological science, and an entirely new field, presenting information upon a multitude of possible dangers to health, has been opened up, suggesting the necessity of precautions which were not dreamed of barely twenty years ago. It is entirely due to this growth of bacteriological knowledge that we are now beginning to understand something of nature's method of purification, or riddance of putrescible matter, and to apply these processes to the cleansing of sewage of foul waters. The great wonder is, that, with bacterial processes actively going on around us at every turn from all time, only now has the great lesson of nature begun to be grasped.

In order to safeguard the public health, it is not enough to know the chemical features of an effluent, and to ascertain that it will not putrefy of itself, but the examination must embrace its bacteriological features as well. The Commissioners, in their Interim Report (1901), observe that—

> "as a result of a large number of examinations of effluents from sewage farms and from artificial processes, we find that, while in the case of effluents from land of a kind suitable for the purification of sewage there are fewer micro-organisms than in the effluents from most artificial processes, yet both classes of effluents usually contain large numbers of organisms, many of which appear to be of intestinal derivation, and some of which are of a kind liable, under certain circumstances at least, to give rise to disease. We are of opinion, therefore, that such effluents must be regarded as potentially dangerous, and we are considering whether means are available and practicable for eliminating or destroying such organisms, or, at least, those giving rise to infectious diseases."

The important subject of the bacteriological purity of filter and land effluents is further dealt with in volumes accompanying the fourth report of the Commission, and the general conclusions arrived at by Drs. McGowan and Houston and Mr. Kershaw are to the effect that (*a*) the effluents from land processes of sewage treatment are not, from the bacteriological point of view, in a proper condition for discharge into drinking water streams; (*b*) the effluents from land possess a bacterial flora characteristic of sewage, and the microbes characteristic of soil are relatively absent from land effluents; (*c*) as a result of its treatment on land, and judged by the bacteriological tests employed in this investigation, sewage does not seemingly become modified in its biological character to any material extent. The bacteria, however, were reduced in number to a marked extent; (*d*) the few samples of subsoil water collected in the neighbourhood of some of the sewage farms were usually found to be pure, both chemically and bacteriologically; but this, of course, must not be regarded as proving that wells sunk in such situations are safe for domestic use, or free from serious objection; (*e*) the samples of water collected above the effluent outfalls, from the rivers into which the effluents from the several sewage farms are discharged, varies considerably. They would all have been condemned bacteriologically from the point of view of drinking water. Even from the point of view of non-drinking water streams their condition was not always satisfactory, either chemically or bacteriologically. Below the effluent outfalls the mixed liquid (river water and effluent) was, under the circumstances, usually not satisfactory. Generally speaking, the discharge of the effluents into the respective streams did not exercise any marked prejudicial effect on the water of the stream; indeed the reverse

was sometimes observed. There seems to be no reason to doubt that the effluents from properly managed sewage farms would, when discharged into non-polluted streams of relatively large volume, neither give rise to any nuisance, nor, so far as may be judged by rate of absorption of oxygen, prove injurious to fish.

Purification of Storm-Waters.—The important question of the necessity and practicability of the purification of *storm-waters* was also considered in the reports aforementioned. "The samples of storm-water examined were almost invariably found to be most impure, both chemically and biologically. . . . The practical advantages of the separate system may be great, and doubtless storm overflows are necessary; but the fact that storm liquids may be so impure, both chemically and bacteriologically, is a point of considerable importance."

Considerable practical difficulty arises in the provision of storm overflows, and their proper adjustment in order that the sewage may pass over the overflow at a given strength or degree of dilution. If, for example, the overflow be fixed at such a height that it may come into operation when the flow exceeds six times the average mid-day flow, it is clear that, owing to the larger volume then passing in the sewers, the overflow liquid would at such a time be much stronger, or more impure, than any similar overflow occurring at midnight, when the ordinary flow at that hour would be relatively very small. In other words the dilution occurring in the latter case would be very much greater than in the former, owing to the widely varying quantities passing in the sewers at the different periods of the twenty-four hours' day. Thus, if the overflow be kept up to such a height as to pass only at six times the mid-day flow, a large quantity of dilute sewage will be sent down to the outfall works to be dealt with. In the case of a farm this may prove very undesirable, inasmuch as the ability of the farm to yield good effluents depends in a large degree on the amount of comparative rest afforded to the land during the night.

Dr. Houston, the expert bacteriologist engaged by the commission in respect of investigations in this connection, in his report regards storm-waters as being "as potentially dangerous to health as normal crude sewage," but recognises the impracticability of treating the whole flow during storms, and adds that "if, for practical reasons, it is necessary to discharge liquids of this kind in the untreated condition into the water-courses, it would seem to be illogical to enforce the adoption of drastic standards of purity in connection with sewage effluents." It has even been suggested that all such effluents should be sterilised before discharge, but such a process, to be effective, would require to deal with the whole storm flow coming down to the outfall, and similar means of sterilisation, which could be suddenly and automatically brought into action, would need to be provided at all storm reliefs or overflows throughout the sewerage system. It is obvious that to install and maintain in readiness for use such means as would be requisite to effect this result would involve an expenditure which may be regarded as quite prohibitive.

At the same time it must be borne in mind that neither chemically nor bacteriologically can mere dilution be looked upon as synonymous with purification, but rather that storm-water is diluted, not purified, sewage.

The practical difficulty of dealing with the storm-water question is largely an emergency one, and where sewage farms are in use for dealing with the sewage an ample area of pasture land should be specially reserved for the overflow of storm-waters. Such storm-water areas should not be used for taking part of the ordinary flow of sewage, but should, as far as possible, be reserved in a condition of readiness to receive large volumes of dilute sewage for short periods. The contouring and preparation of the land for the proper distribution of the sewage will depend on the slope of the ground and nature of the soil, but the treatment should be one of surface irrigation without underdrainage.

Where land is not available, special storm-water filters, constructed as shallow bacterial continuous or streaming beds must be installed, and the area provided should be on the basis of a maximum rate of filtration of 500 galls. per square yard. These beds should not lie idle between storm periods, but the bacterial growths should be maintained by treating thereon a small proportion of the ordinary dry-weather flow at a low rate of filtration.

The attitude assumed with regard to the treatment of storm-waters is one of vital importance, for if it be authoritatively held that the storm-liquids carried away by the "separate system" of sewerage are not in a fit state to be discharged direct into the nearest water-course, the future policy of local authorities with respect to new sewerage and sewage disposal schemes will need to be very materially modified.

However desirable the full treatment of

storm-waters may be as a counsel of perfection, sanitary authorities and their engineers have to deal with the matter from the practical point of view, with special regard to the financial considerations involved. No process of treatment will probably ever be in use which will yield 100 per cent. of purification either bacteriologically or chemically, and it is probable that the purity of the effluents as now discharged from properly installed bacterial systems and well managed sewage farms is carried sufficiently far for all practical purposes. At any rate much evidence is needed as to the pathogenicity of effluents so discharged before the practical necessity of higher standards of purification can be reasonably called for.

The Systematic Examination of Sewage Effluents.—Much has been made by some of the reluctance of local authorities in regard to the spending of money in the regular analysis of effluents discharged from their works, but it must be remembered that occasional analyses are of little practical use, as the conditions of the effluent may vary from almost hour to hour, and that constant watchfulness and average results of daily analyses are necessary to keep the performance of the sewage disposal system under close observation. This points to the necessity of engaging a resident chemist and bacteriologist—an expense which any but the larger authorities can scarcely be expected to incur.

At the same time, the present writer is of opinion that much more attention should be given to the systematic examination of the effluents discharged than has hitherto generally been the case, and if those in charge of farms and bacterial systems could be induced to take an intelligent interest in the daily performance of their works, by the application of some simple practical tests coupled with the experienced use of the senses of smell and sight, a large amount of most valuable work may in this way be accomplished, which, in the course of a very few years, would have a marked effect upon the purity of our rivers and watercourses.

In this connection, the practical value of regular attention to such matters as the colour, odour, behaviour in keeping, and power to support fish life, of sewage effluents cannot be too firmly insisted upon. On this subject the observations of Dr. J. A. Voelcker, consulting chemist to the Royal Agricultural Society, before the present Royal Commission on Sewage Disposal, are particularly significant. In speaking of the application of some simple test by the sewage works manager, he says: "I should be very sorry to try to make chemists out of them. I think the ordinary indications of freedom from matter in suspension and freedom from smell are about as good ones as either he or a chemist could have. *Even speaking as a chemist, I should attach more importance to the observation of my eyes and my nose as to whether it was a pure and proper effluent than as to whether it contained this or that number of grains per gallon of this or that constituent.*"

One of the most simple but valuable tests is, that of the behaviour of an effluent on keeping. The most important character an effluent can possess is, that it should show no signs of putrefaction upon being kept for several days in a closed vessel at a temperature of 80° F. This may be at once regarded as proof of the impossibility of such an effluent creating a nuisance in any watercourse to which it may gain access, and shows that great purification has been attained.

A distinction, however, must be drawn between the effluents produced by sterilization as by the aid of some chemical, and those derived from sewage farms and bacterial systems. The effluent produced by chemical precipitation may keep for a considerable time and apparently satisfy the test, but yet be capable of putrefaction when suitable conditions arose. The actual reduction of the dissolved impurities may be insignificant, and the after-putrefaction of the liquid is simply deferred until the effect of the precipitant used is worn off or the effluent has become sufficiently diluted to prevent its further action. An effluent from a precipitation works, for example, containing a large excess of lime will putrefy upon dilution, and it is in this respect that effluents from farms and bacteria beds possess such great advantages over those obtained by chemical agencies.

This test, the behaviour of the effluent on keeping, and that of the power of the effluent to maintain fish life, are the best that can be applied, and are sufficient to give a practical guidance as to the character of the effluent being sent away.

The dissolved oxygen found in clean river water is essential to the support of fish life, and, when the latter disappears owing to the pollution of the water with sewage, it is usually due to the reduction of the amount of free oxygen in the water which is used in oxydizing the polluting organic matter. The fish are thus suffocated when the amount of oxygen becomes too small for purposes of respiration. To follow out this test, a few gold fish may be

kept in a glass globe supplied daily with fresh sewage effluent.

This question of the ready application of practical tests has an important bearing upon that of the desirability of adopting fixed standards of purity in regard to sewage effluents. Any such standard to be of service must be one that can be systematically applied by the man on the spot whose duty it is to see to the daily character of the effluent discharged. Universal standards are undesirable and impracticable. For example, it would obviously be absurd to require that a sewage effluent discharged into the tidal estuary of the Thames, Mersey or Clyde should attain to the same chemical and bacteriological standard of purity as that discharged into the upper parts of an inland stream from which water is taken for the supply of a population lower down. The object to be attained in each case should be to turn out such an effluent as shall, having full regard to all the local circumstances, produce no nuisance or incur no danger to the public health of the district through which the stream flows. The extreme case demanding the highest standard of purity is obviously that in which the watercourse is the source of a population's water supply.

Rules in connection with the design of Sewage Disposal Works.—The same variety in the requirements necessary to satisfactorily meet local circumstances manifests itself in regard to the preparation of a fixed set of rules or regulations having for their object the guidance of engineers engaged upon the design of sewage disposal schemes. The question of the sewage disposal of a town, like that of its water supply, is usually a problem which must be carefully studied, not upon mere abstract principles, but with special regard to the actual possibilities presented by the locality itself. Herein lies the crux of the engineer's task in the useful application and adaptation of the conditions locally provided by nature for the use and convenience of the inhabitants to be served. In such circumstances fixed rules or requirements are likely to do much more harm than good by hampering the designer, by reducing his task to a mere matter of simple arithmetic, and so thereby precluding the employment of local conditions and the latest researches and advances in science to the utmost advantage.

(*To be continued.*)

Rail Corrugations.

THE corrugation of rails is a phenomenon which is at present occupying much attention among railway and tramway engineers. This mysterious complaint which has already caused a great deal of annoyance to the travelling public in India is now making its appearance on the electric tramway lines of this country and in some cases has involved considerable expense in renewals.

Some eighteen months ago the Municipal Tramways Association appointed a small sub-committee for the purpose of enquiring into the question and members visited various towns to try to elucidate the cause or causes of this condition. So far, however, no report has been issued, probably owing to the circumstance that they have not been able to agree upon any special reasons for the serious state into which the tracks have fallen over long lengths of tramway lines. This subject has been taken up also in America, and on the Continent and in India attention has been drawn to it on some of the railways. The Technical Committee of the Tramways and Light Railways Association are also taking up the question, and as a result of a suggestion put forward in their circular for April—that data should be collected from the principal users of rails throughout the world—several communications have been received, notably one from Sir Frederick R. Upcott, K.C.S.I., President of the Indian Railway Board.

In his communication to the Tramways and Light Railways Association,* Sir Frederick states that "roaring rails," as they are termed in India continue to give a great deal of annoyance He mentions the extraordinary fact that brick ballast has a tendency to develop the corrugation, and that on the Eastern Bengal State Railway in a great many instances brick ballast has had to be taken out and sand and earth or stone substituted. A technical paper by Mr. G. Moyle, M.Inst.C.E., Engineer-in-Chief, Eastern Bengal State Railway, issued by the Government of India, is reproduced in the circular, of which the following is an extract :—

The term roaring originated on the Eastern Bengal State Railway some ten years ago, and may be defined as the noise caused by the development of furrows across the running head of a rail, usually oblique to its length, the tops of the furrows being very hard and the bottoms soft. Such rails are also described as "Corrugated." They do not in the least resemble galled or pitted rails.

The common objection to these rails is that they occasion a deafening noise when trains are passing over them, which causes great discomfort to passengers. To give an impression of how objectionable the noise is, it may be stated that two persons inspecting the line by light trolley, cannot possibly converse, even by shouts, when running over a continuous section of these rails.

The engineers of Indian railways have had roaring rails under observation for the past eight years, but up to the present no definite conclusion has been formed on the real cause of the phenomenon, and no manufacture-specification has been drawn up with a view to produce a metal likely to be exempt from its development.

The accompanying illustrations show reproductions of photographs prepared to give clear ideas of the superficial appearance and microscopic structure of such rails. The mean pitch of the corrugations has been found to be 0·74 inch, and the mean depth 0·0035 inch.

The following are the principal ascertained facts concerning the phenomenon :—

(*a*) Both double-headed and flat-footed rails develop it ; it is not confined to any particular weight or section, or to double or single line. (*b*) It develops in rails rolled by various manufacturers. (*c*) It develops with equal facility on banks or cuttings, grades or levels, straights or curves. (*d*) It appears to be found more generally in extremely damp climates, especially when the atmosphere contains salt brought from

* Circular for July.

the sea; but it is found in a variety of climates, and even in exceptionally dry inland tracts. (*e*) It develops most rapidly where brakes are freely used; for instance, just outside and inside station signals; but it is not necessarily produced by brake action, since it exists abundantly in parts of tracks where brakes are never put down. (*f*) Cases are common in which a roarer occurs, while the rails fished to it or immediately opposite it in the track, though delivered by the same manufacturer in the same year, do not roar. (*g*) Roarers taken out of the track, planed smooth, and replaced, have again developed roaring. (*h*) Roarers almost invariably develop where the track is packed and boxed with brick or burnt-clay ballast, and on open girder bridges. (*i*) Roarers are scarcely ever found where the ballast is stone, and never where the track is packed and boxed with earth. (*j*) Roarers on brick-ballasted road can be got smooth if the brick boxing is removed and replaced by earth. The trains then wear the rails smooth. It is not necessary to remove the brick-ballast packing under the sleepers. (*k*) Roaring has only been found in steel rails and never in an iron rail. One lot of steel double-headed 73-lb. rails delivered about 1880-82 have never developed roaring though packed and boxed with brick-ballast, and subjected to the same conditions which have attended roaring in adjacent rails. (*l*) Roarers have been cut into thin slices, both parallel and at right angles to the vertical axis. (*m*) The ridges of a roaring rail resist a file, but the metal in the hollows is removed quite easily. (*n*) It has been found dangerous to reverse double-headed roarers in the track, *i.e.*, to place them upside down, as they have been found to fracture. It is also undesirable to change the positions of sleepers under flat-footed roarers. This also leads to fracture. (*o*) So far as roaring rails have been examined by experts, their opinion is that there is nothing in the chemical composition, physical condition, or microscopic structure to explain the phenomenon.

The following are amongst the causes of roaring suggested by various engineers:—

(*a*) To vibrations set up in some unknown manner on an imperfectly packed road in a yielding formation, and that once this cause is removed and the vibration arrested the effect will also be eliminated and the wear become even. (*b*) To portions of the rail rusting away under the action of dew, and leaving ridges, the cause of this being want of homogeneity in the metal. (*c*) To rails after rolling being stacked whilst hot in layers crossing each other at right angles, so that unequal cooling is produced, the surface being annealed locally at uneven intervals. (*d*) To accidental irregular cooling after rolling. (*e*) To the ingots from which the rails were rolled being cooler than they should have been. (*f*) To the effect of brakes which lift the wheels from the rails. When this happens, the brake ceases to act and the wheel falls down on the rails; the brake begins to act again, and so on. the flexibility of the springs accentuating this undulatory motion. (*g*) To wheels being braked with maximum retarding force, which is just short of skidding; that is to say, by a force on tyres rather less than the weight of the vehicles on the rails. This is brought about by a vibratory action set up in bearing springs by the jolts occasioned in passing over the joints. (*h*) To excess of manganese in the metal. (*i*) To the existence of alternating lenticular masses of pearlite and ferrite. (*j*) To the rails being finished from the rolls at an improper temperature.

To give an idea of the extent to which roaring can develop under favourable conditions, it may be stated that in a section of metre-gauge single track on the Eastern Bengal State Railway between Dacca and Mymensingh, 12½ continuous miles of which were very carefully inspected, all roarers and non-roarers being counted, it was found that 89 per cent. of the rails were roarers. The traffic in this section is light, the speed low, the track maintenance excellent. No continuous brake is, or ever has been, used. On the other hand, the section examined is brick ballasted, the climate is extremely moist, the rainfall excessive, and the atmosphere is said to be charged with salts.

The following is a note on a piece cut from a typical rail taken out of the above nest of roarers: "Measurement of depth and pitch of all the corrugations in a piece of roaring rail from the Dacca section, Eastern Bengal State Railway (41¼ lbs. steel flat-footed):

"34·54 ins. long.

Depth of corrugations.

Maximum	0·0068 in.
Minimum	0·0011 in.
Mean	0·0035 in.

Pitch of corrugations.

Maximum	1·14 in.
Minimum	0·50 in.
Mean	0·74 in.

"There appears to be no relation between pitch and depth, but generally greater depth goes with greater pitch."

An extract from an official report made in January, 1902, is given below:—

(1) A roaring rail was found fractured on the line, between Chogdah and Ranaghat, Eastern Bengal State Railway, on December 26th, 1901. (This line is double track laid with steel 73-lb double-headed rails,) (2) The permanent-way inspector had reversed this rail a few days before its fracture, and it is thought that there can be no doubt that this caused the fracture, and that the reversal or turning upside down of steel rails is a dangerous practice. (3) Two pieces of this rail have been kept, so that they may be sent to England for thorough examination and report. (4) The original head of the rail, which shows the alternations of hard and soft metal which are characteristic of roaring rails, displays unmistakable skin cracks across the head at the places where the soft metal exists, and apparently fracture has occurred through one of these skin cracks. (5) As far as is known, these skin cracks are not generally noticeable in roaring rails; but it is quite possible that they exist, and that microscopic examination would discover them.

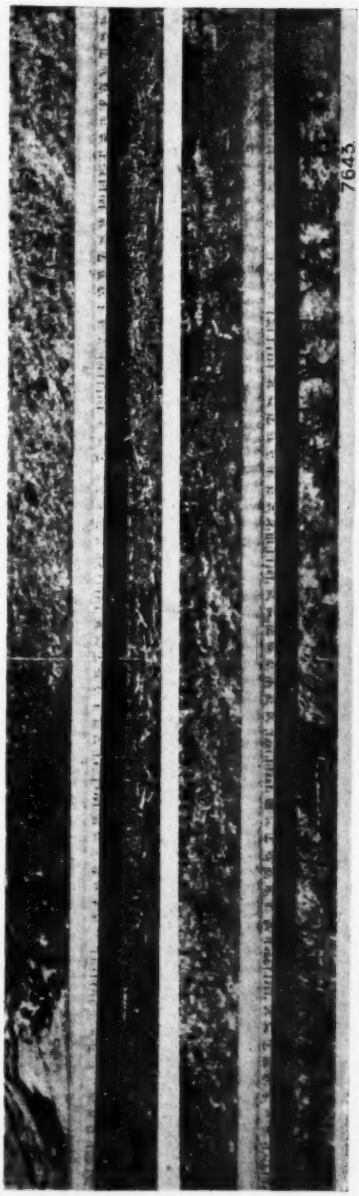
If skin cracks are general in roaring rails there can be no doubt that they constitute a serious defect. The two pieces of this rail were forwarded to England for examination, and one piece together with two other pieces of rail sent to England on former occasions were examined in the laboratory of the Royal Indian Engineering College, Cooper's Hill.

The following is the report submitted from that laboratory; and it should be noted that No. 2020 is the roaring rail which fractured:—

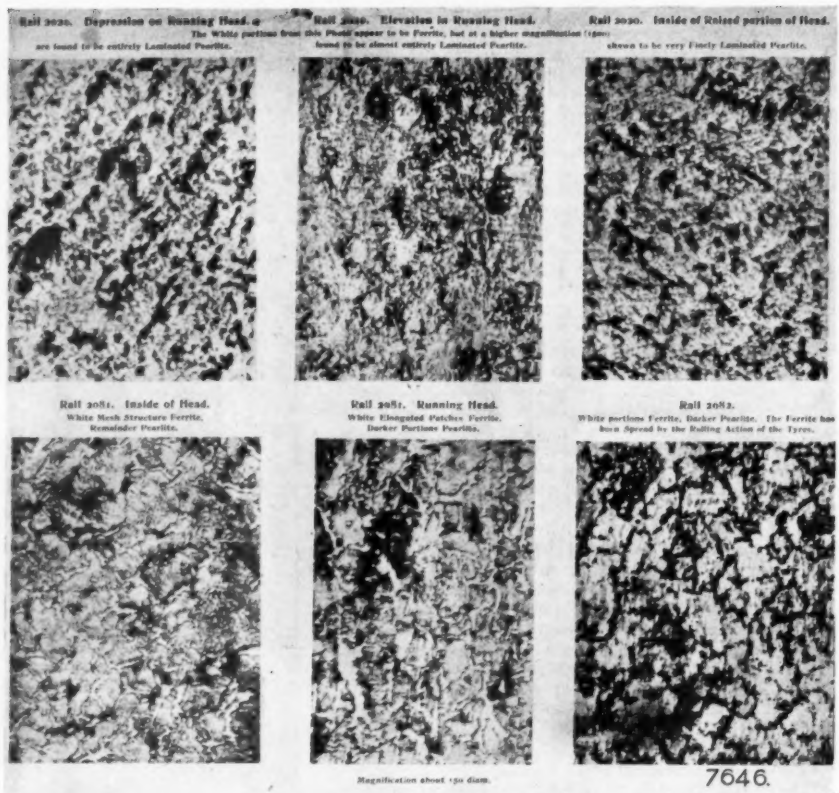
"I have very carefully examined the three rails submitted to me, and neither from the chemical composition, physical condition, nor microscopic structure, can find anything to explain the phenomena, and I feel convinced that the unevenness of the surface which is responsible for the roaring is not due to the chemical composition or physical state of the rail, but to some local cause. The following are the results of the analyses. In the case of No. 2020 samples were taken from both ends of the rails, but no appreciable difference was found in the analyses:—

No. 2020.
Roaring Rail.
Referred to in letter 15th March, 1902, No. 418 M. S., Eastern Bengal State Railway, marked 000.

Carbon	0·691
Silicon	0·148
Sulphur	0·067
Phosphorus	0·078
Manganese	2·090



HEAD OF A TYPICAL ROARING RAIL.


Rail 2020. Depression on Running Head. a
The White portions from this Photo appear to be Ferrite, but at a higher magnification (150 diam.
are found to be entirely Laminated Pearlite.
found to be almost entirely Laminated Pearlite.
Rail 2020. Elevation in Running Head.
Rail 2020. Inside of Raised portion of Head.
shown to be very Finely Laminated Pearlite.
Rail 2081. Inside of Head.
White Mesh Structure Ferrite.
Remainder Pearlite.
Rail 2081. Running Head.
White Elongated Patches Ferrite.
Darker Portions Pearlite.
Rail 2082.
White portions Ferrite, Darker Pearlite. The Ferrite has been Spread by the Rolling Action of the Tyres.
Magnification about 150 diam.
7646.

Rail 2082. Inside of Head.
Pearlite Ferrite. Dark Areas Pearlite. Magnification about 150 diam.
7644.

A
Pearlite
B
Ferrite
7645

No. 2081.
Roaring Rail.
Marked Steel I. S. R. 73 lbs. IX., 1885, B. & Co.

Carbon	0·472
Silicon	0·052
Sulphur	0·124
Phosphorus	0·100
Manganese	1·050

No. 2082.
Worn Rail.
Marked 43285, 18th December, 1901, sent for comparison.

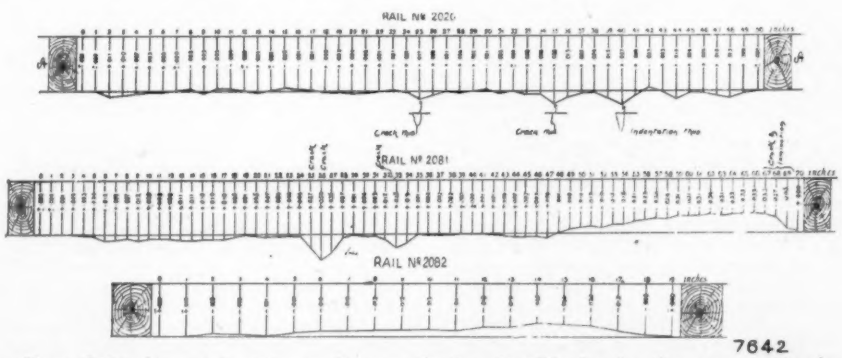
Carbon	0·459
Silicon	0·569
Sulphur	0·076
Phosphorus	0·058
Manganese	0·950

"Rail 2020 is quite abnormal, containing over 2·00 per cent. of manganese. It was extremely hard, and could only be sawn up with the greatest difficulty, and cracks in numerous places extended into the running head to a depth of half an inch. Under high powers of the microscope (1,500 diameters), the structure is almost entirely pearlite, there being little or practically no ferrite, which is what one might expect from the percentage of carbon. The other rails were fairly normal as regards composition, except the high silicon in No. 2082, and both these give normal micro-structures of ferrite and pearlite. Photographs of the raised and depressed portions of rail 2020 and from the other rails are enclosed (reproduced in the illustrations); 2020 under the low power, 150 diameters, appears to consist of ferrite and pearlite, but at a higher power this is not the case. The diagrams show the depths of corrugations on the surfaces of each running head, and it will be seen that these are most irregular. A suggestion was made in the correspondence that the uneven wear of the rails might be due to alternating patches of ferrite and pearlite, that the soft ferrite being more readily worn away than the pearlite; but when it is remembered that the ferrite areas are microscopic and never exceed $\frac{1}{1000}$ * of a square inch in any of the rails, the impossibility of having alternating patches an inch or more in length will be fully realised. From the abnormally high carbon and manganese and hardness of rail 2020, it might be assumed that the roaring was due to this, but this assumption is at once negatived by the composition of rail 2081, which is a fairly soft normal rail, and behaves in the same way. Consequently the only conclusion to be drawn appears to be that the roaring is not due to any peculiarity in the rail itself."

The Board of Trade, England, some fourteen years ago, appointed a committee to inquire into the loss of strength in steel rails through use on railways. Their report was published as a Parliamentary Blue-book in 1900, and the following extract is taken from page 71, as it may possibly throw some light on the subject of this paper:—

"Another important point illustrated by these results is the influence exerted on the character of atmospheric corrosion by the unequal distribution of iron and carbide of iron in the rail, which is particularly marked in the presence of much manganese. When, owing to the method of annealing and other processes to which the steel is subjected

* $\frac{1}{1000}$ in. is the actual figure stated in the copy of the Cooper's Hill Laboratory Report which reached India, but is believed to be erroneous.



NOTE.—Packing pieces *A A* exactly 1 in. thick were placed on the rail-head, and on these a true straight edge. Measurements were taken by a vernier gauge between the straight edge and rail-head at intervals of 1 in. The sign + denotes the depressions below the datum line, and the sign − elevations above the datum line. The elevations and depressions are shown ten times greater than they actually measured.

during manufacture, the iron is deposited in large veins and laminæ, the micro-photographs appear to show that these are eaten out by atmospheric corrosion forming superficial furrows, the extent and significance of which remain to be determined by further experiments. So far as the evidence goes at present, it appears that while they probably lead to increased loss by wear and tear, there is no proof that they are starting points for fractures in the rails."

From the concluding words of the extract given in the preceding paragraph it would appear that it was suspected in 1890 that skin cracks might exist in furrowed or corrugated rails, and the report on rail No. 2020 now confirms this suspicion; though in the case of that rail the excess of carbon might account for them.

The only important fact evolved from the examination of the rails at Cooper's Hill is that the roaring rails contained an excess of manganese. This has been put forward as a cause, *vide* above.

The Locomotive Superintendent, Burma Railways, wrote as follows in 1899:—

"I, however, hazard an opinion that the mischief will be found to be confined to the steel made in the early eighties of the expiring century, all of which has an excess of manganese." This opinion rather conflicts with what is stated above, but this may be accidental.

Extracts from various inspection reports regarding roaring rails are given in the circular, from which the following are chosen:—

The district engineer of the southern division, Indian Midland Railway, says: "I have noticed the phenomenon in a few scattered rails of the Indian Midland Railway 80 lb. steel type, and an examination has invariably shown that the roaring was due to inequalities caused by worn rails." The Indian Midland Railway is generally laid with 80 lb. flat-bottomed steel rails. At present the matter does not appear to have assumed a serious aspect on this railway, at any rate so far as the 80 lb. steel rails are concerned. Wherever unevenness of wear is discovered, I should be glad for pieces of the rails to be cut out and sent to me with particulars of the traffic passing over them, and of the position in the road from which they were taken, whether where the brakes are generally put on or otherwise. I regret that, in the absence of complete data, I am unable to give "an explanation of the cause of roaring in rails," as desired by the agent. On receipt of further information I will go further into the matter.

Major O. Thackwell, R.E., Government Inspector of Railways, of the Bengal Central Railway, reports that the rails are 62 lbs. steel, flat-footed, and have been about 15 years in the road: no considerable renewals are yet found to be required, seven rails only having been renewed during the last half-year. The noisiness of the rails—not throughout but in many different places—was very marked, and is a source of so much discomfort to passengers that it would appear advisable to consider whether it is not possible to find a remedy. From enquiries on this line and on the Eastern Bengal State Railway and from personal examination, I find it generally agreed that the noisiness is caused by corrugations on the rails, due to portions of the rail rusting away under the action of dew and leaving ridges, the cause of this being want of homogeneity in the steel of the rail. This would point to the necessity for a more strict inspection of the process of manufacture on the part of the buying agency in England, so as to prevent this irregular wear in the case of future consignments of rails.

The Engineer-in-Chief of the Eastern Bengal State Railway reports that the development of the peculiar wear resulting in roaring is general throughout both the standard and metre gauge systems in all steel rails, whether double-headed or flat-footed, except in some 72 lb. double-headed rails 20 ft. long, laid in the Goalundo extension, when the standard gauge section belonged to the Eastern Bengal (Guaranteed) Railway previous to 1879. It has not developed in the 25 lb. steel flat-footed rails of the 2 ft. 6 in. lines; but the traffic there is extremely light and the brake power comparatively small.

The wear is most pronounced and occurs more rapidly where brakes are generally applied, that is, near distant signals of stations. It is decidedly more general and continuous in the Dacca section, which is laid throughout on 41¼ lb. steel flat-flooted rails, laid about 1884. The upper surface of a rail which has developed roaring usually consists of a series of hard lumps or bars projecting above the general level of the rail top, the lumps being at fairly equal distances. These lumps resist a file, but the metal between the lumps is removed quite readily by a file. A pair of double-headed steel rails which had developed roaring near Kanchrapara were removed, and the top table planed smooth. Within

12 months one of the rails had commenced to develop the same wear. The fact that roaring is general, and that no steel rails, except those mentioned above, seem to be exempt, would seem to point to the conclusion that the defect is due to some peculiarity in the specification to which the rails are manufactured.

The executive engineer, Bhatinda, North-Western Railway, states that the roughness of the rails varies from mere pitting to a continuous series of hollows and indentations, and suggests it is probably due to the rails after rolling being stacked whilst hot in layers crossing each other at right angles, and that unequal cooling is produced, the surface being annealed locally and at regular intervals. He adds that the matter was thoroughly investigated on the Burma State Railway, and the conclusion arrived at was that roaring rails chiefly existed where trains were braked, the hollows being produced by the jumping motion of the vehicles.

The executive engineer, Karachi, states that in the case of new 75 lb. f.f. rails roaring is due to a series of shallow ridges running across the rails at an angle of about 60 deg. to the axis of the rail and from 1 in. to 1½ in. apart, and that these ridges existed in the rails before they were laid and are not due to wear. The rails roared the first time a train went over them, but the roaring is less now than it was when the rails were first laid. There are no signs of flaw, but merely the corrugations referred to, and he is therefore of opinion that the defect in the rails is due to faulty manufacture. In the case of 68 lb. rails, the roaring, he says, was due to small circular nobs of very hard metal, and in this instance he has no doubt that the state of the rail surface was due to brakes.

The Deputy Consulting Engineer for the Madras railways, remarks that in his experience he found that certain 75 lb. double headed steel rails laid in the Mushkaf-Bolan Railway developed the roaring peculiarity, but in their case it was obviously due to the fact that those particular rails were pitted with rust and had been originally laid on the temporary Bolan line where they had been subjected to floods. The worst case that came under his observation was while travelling as a passenger between Pano Akil and Reti on the North Western Railway. Certain lengths of the rails in this section were very noisy during the passage of the train, the sound being very similar to that made in passing over an open girder span. He never examined these rails, but attributed it to the pitting due to exposure in salt water, as it is believed that many of the rails used on the old Indus Valley on arrival from England were beached at Karachi, and were often submerged at high tide.

Reports from executive engineers on the East Coast Railway are to the effect that there have been several cases of roaring rails, and in those cases where the noise was very great, the rails have been removed from the main line. The worst case was noticed when about 200 rails, which had been laid for some months at the wharf and had occas onally been submerged under the sea, were included in a consignment sent out to be laid near Delang on the Puri Branch plate-laying. These rails were pitted all over their tables to a depth of about $\frac{1}{32}$ in., and the noise while running over them was deafening. Rust is held to be the cause of the rails wearing so as to cause roaring.

A great many rails in another division have the same defect. The cause of the corrugation is well known. Corrosion of rails is due to sea air and salt water. The rails are corrugated before a wheel had touched them. The executive engineer has formed a theory on this subject that the rails which suffer in this way were rolled from ingots cast when the steel was colder than it should have been. The steel is poured from the converter into a pot and allowed to run from the latter direct into the ingot mould. The stream would, when the steel is not perfectly liquid, fall, like all viscous liquids do (treacle, for instance), in folds, and the outside skin would be hardened slightly by contact with the air and would form when rolled out alternate hard and soft places.

The Superintendent, Way and Works, Burma Railways, remarks: "Roaring rails are generally found at approaches to stations where brakes are first applied. They are more frequent amongst the 41½ lb. rails than amongst those of the heavier sections, which is probably due to the lighter rails having undergone more work. There are no roarers amongst the iron rails. This noisiness is caused by the wheels rolling over slight corrugations on the head of the rails."

These corrugations may be due to the repetition of the following process: "The application of the break lifts the wheels from the rails; when this happens the brake ceases to act and the wheel falls down on the rails, the brake then begins to act again, and so on, the flexibility of the spring accentuating this undulatory motion."

The Locomotive Superintendent remarks: "Roaring rails may be found approaching

every station between Prome and Toungoo, where the rails are about ten years old or older with a heavier traffic over them. The worst places are just above where the brakes are first applied with trains at high speed, when skidding rarely or never occurs. As the station yard is approached, where more or less skidding constantly occurs (with decreasing speed), there is not a sign of the roaring corrugations, but the rails are smooth and brightly polished. The rails approaching Krunnendine from the north on the up line are now commencing to roar, being just about ten years old. I have detected no roarers north of Toungoo yet, though the line to Mandalay is now eleven years old, but the traffic has not been heavy. The old rails laid into the Meiktila branch a few years ago are roaring badly.

"I feel convinced that the corrugation action on the rails is produced by wheels being braked with maximum retarding force, which is just short of skidding—that is to say, a force on the tyres rather less than the weight of vehicles on rails. I also feel pretty sure that this is brought about by a vibratory action, set up in the bearing springs by the jolts occasioned in passing over the rail joints. I hazard an opinion that the mischief will be found to be confined to the steel made in the early eighties, all of which has an excess of manganese. This same steel rusts fearfully, and the rusting occurs in a pitted form very much allied in appearance to the corrugations formed on rails."

Facts collected by the Assitant Engineer of the Eastern Bengal State Railway tend to show that roaring develops almost entirely on ballasted road.

The rails inspected are on the Dacca section, between miles 10½ and 23, and between miles 76½ and 86. The total number of rails looked at was 9,675; out of this 5,494 are "roarers," or about 57 per cent. The road is ballast-packed and boxed (except at level crossings) along certain sections. On this portion out of a total of 6,180 rails, 5,487 are roarers, equalling a percentage of about 89. The remainder is packed and boxed with mud. Here, out of 3,467 rails, seven roarers were found, 0·2 per cent. The total number of rails in cutting is 448, and out of these 396 are roarers, or, roughly, 90 per cent. It has been noticed that roaring scarcely exists on stone-ballasted road, whereas it is not uncommon in brick-ballasted road.

The so-called "noisy" or "roaring" rails were noticed on many parts of the northern section of the Eastern Bengal Railway notably on the Katihar and Anchara lines, but nowhere has the phenomenon developed to such an extent as was observed during the inspection of the Dacca section.

With regard to these rails the following points were noticed:—

(1) They are not found in cuttings or on solid ground, being met with only on banks and open bridges. (2) They develop only on a road carried on coarse broken ballast, especially on brick ballast, and are never found on a road boxed up with earth, or where a ballasted road is chocked with earth, as at a level crossing. (3) They do not appear to develop on a road carried on cast-iron sleepers, certainly not to the same extent as on a wooden sleeper road. But when rails which have already developed roaring are laid on cast-iron sleepers they continue to roar. (4) They are not confined to the proximity of stations or localities where the speed is liable to systematic checks. (5) On an experimental length near Dacca, where the rails are very badly corrugated, and where the ballast had some months previously been removed from one side of the centre line and replaced by earth packing, it was observed that the rails on that side are unmistakably wearing evenly, and the corrugations gradually disappearing, whereas those on the side over the ballast show no such signs. (6) They are not confined to rails of any special make or section, but are found on many different types on the Eastern Bengal State Railway. (7) Such rails appear to be unknown on well-maintained roads, such as the East Indian Railway, the North-Western Railway, and the English railways.

From these facts it does not appear to be unreasonable to assume that this irregular wear on certain rails is due, in the first place, not to any inherent defect of the rail, but to vibrations set up in some unknown manner on an imperfectly packed road on a yielding formation, and that once this cause is removed and the vibrations arrested, the effect will also be eliminated and the wear become even.

Another report states that on the Eastern Bengal State Railway it was noted that roaring rails occurred only where brick ballast was used, and when this was renewed and good stone ballast substituted, the rails were gradually worn smooth again. In all the cases noted on this railway, the ballast was of broken brick, called locally "dillon." With few exceptions they occurred just outside station yards, in such positions as to make it reasonable to suppose that the application of the brakes, and consequent dragging or skidding of wheels is a principal

agent in producing the corrugations of the surface to which the roaring is due. It is also noticeable that over the same length of rails the roaring is more pronounced when the train is leaving the station, than on entering it.

But though the dragging of the wheel under the application of the brakes may be the active agent, it may still be that broken brick ballast in moist localities produces an effect on the surface of the rail, predisposing it to be furrowed by this action, and if this predisposing cause is removed the nuisance may be abated.

The phenomenon, as manifested in connection with tramway rails, has been investigated by an engineer in this country,* who found that corrugation was principally due to the looseness of the rail, which vibrates as the car passes, resulting in a gradual pounding of the rail tread. The lines most subject to the complaint are those where rails have been laid on the concrete foundation without anchors. Grinding was resorted to as a remedy, but was only found satisfactory where anchor chairs had been inserted.

Rail corrugation has also been noticed in the rails of the Berlin Elevated Railway, and Von Borries* holds that it is due to want of rigidity in the track; another authority, however, attributing the action to a backward slide of the outer wheel on the rail on curves.

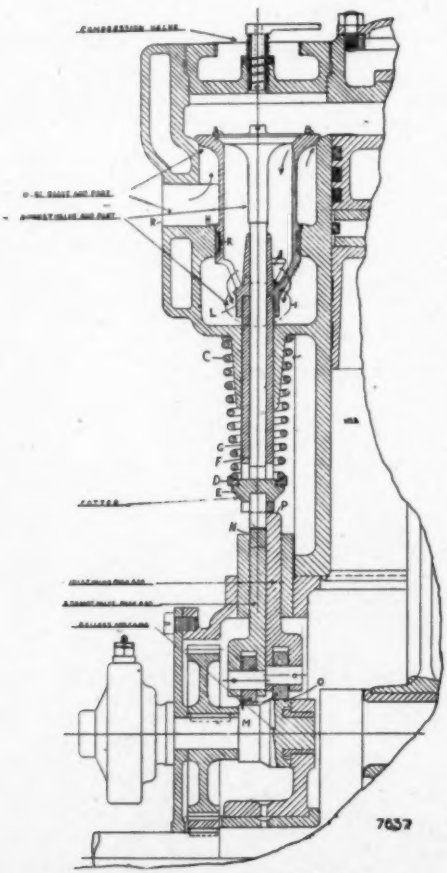
* *Electrical Times*, July 6th and 20th, 1905.

* *Science Abstracts*, p. 516, 1905.

Automobile Engineering.

By ROBERT E. PHILLIPS, M.I.Mech.E., A.M.Inst.C.E.

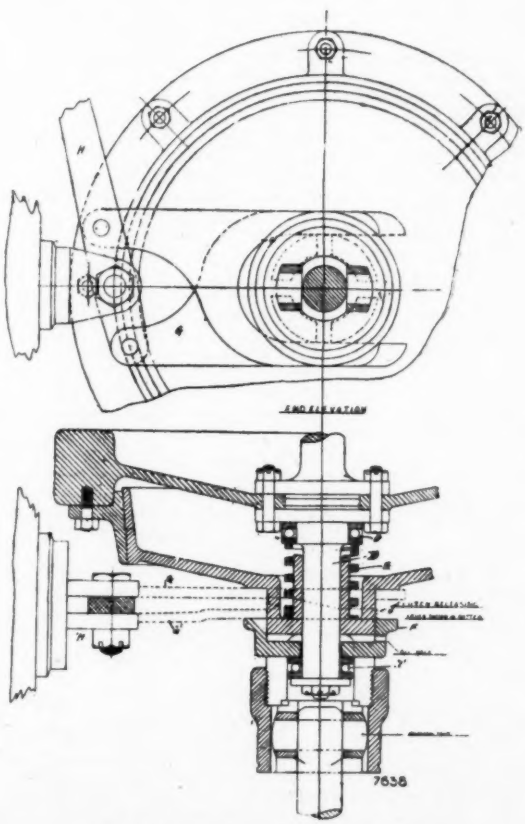
The "Parsons" Marine Motor.—This motor, which has been specially designed for marine work, uses either petrol, paraffin, or alcohol as a fuel, and in trials recently held the paraffin consumption was less than one-tenth gallon per horse-power hour. In the first place, no external vaporiser is used, nor any lamp for starting, so there is no possibility of its blowing out, or ejecting burning oil, or requiring cleaning. Instead, a small additional tank is fitted containing as little petrol as one wishes to put in it, and both this tank and the main fuel tank are connected, each with a shut-off cock, to the same carburettor, which is of the ordinary petrol type, and not what is known as a paraffin carburettor. After running for a few minutes on petrol, the paraffin is turned on, and the engine continues to run with no more smoke or smell than with petrol. Referring to the section it will be seen that the valves are combined, and that the exhaust valve is seated upon the hollow tubular inlet valve. The exhaust passing through the latter heats it up and emerges through ports at the bottom of the valve and away out at the exhaust connection. The incoming charge impinges upon this hot valve and is vaporised; but, be it noted, only the moment before it enters the cylinder. When using paraffin, there is no vaporisation in the carburettor and no additional heat required for it, and therefore there can be no subsequent re-condensation in pipes between carburettor and inlet valve. The vaporisation is perfect, and the amount of heat such that no prejudicial effect is noticed even if the engine continues to be run on petrol. Both valves are mechanically operated by separate cams, but whilst the exhaust valve has full lift, the inlet valve, owing to its large area, has about half the lift of the exhaust, yet the opening is the same, owing to its large diameter. No extra work is put upon the cams and rollers, as the large valve only lifts on the suction stroke. One spring, cottar, and washer closes both valves, and on the exhaust stroke the inner valve only lifts, whilst on the inlet stroke both lift together, the exhaust remaining seated upon the inlet. The engine has a heavy fly-wheel, causing steady running, large and long bearings, which are adjustable, and bearings between each crank in two and four-cylinder models. All gear wheels are enclosed, and there is only one cam shaft. The crank chamber may be taken apart without disturbing the crank shaft, &c.



VAPORISING VALVE GEAR: "PARSONS" ENGINE FOR PETROL OR PARAFFIN.

Ample water space, easily cleaned out, is provided around cylinder and valves, the cooling water being supplied by a pump as usual. Lubrication is automatic to all parts, through sight drip and one oil lead. Battery and coil ignition is usually supplied, but magneto can of course be supplied if preferred, or in duplicate.

Another feature of the "Parsons" motor is the clutch, which is so constructed that there is no unbalanced end thrust either when the clutch is in or out of action. On reference to the illustration it will be seen that the fly-wheel *A*, which is fixed to the crank-shaft by bolts in the usual manner, has attached to its rear face an internally-coned flange *Al*, which forms the contact face for the outer member *B* of the clutch. Bolted to the crank shaft *C* is a short clutch shaft *D*, which carries the other, or internal, member *B* of the clutch. Abutting on a collar on the shaft *D* is a ball thrust bearing *d*, and at the opposite end is a similar bearing *dl*, which take between them the thrust of the clutch spring *E*. Between the bearing *dl* and the boss of the internal part *B* of the clutch is a flanged collar *F*, which is in connection with the said internal part *B* by means of a star-shaped plate. The clutch is operated by means of two forks *G* and *Gl*, connected respectively above and below the fulcrum of the clutch operating lever *H*, so that when the latter is moved one fork is pushed inwards and the other pulled outwards. These forks have each an inclined plane face so that relative motion between the two forks causes the total width of the two to be increased. The effect of this is that the groove *J*, formed by and between the shoulder of the inner clutch member *B* and the flanged collar *F*, becomes of insufficient width for the forks when moved over one another, consequently the forks operate to force the inner clutch member *B* out of engagement with the part carried by the fly-wheel. The end strain set up is absolutely self-contained, as it is equal and opposite between the two ball thrust bearings. It will therefore be seen that whether the clutch is in or out or being slipped there is at no time any end thrust upon the crank shaft. Each of the operating forks *G* and *Gl* is free to move sidewise, a certain amount, upon the pin connecting it to the clutch lever, so that the outward faces of the forks are always perfectly parallel with the faces of the clutch shoulder and the thrust washer respectively. An important feature of this clutch is that when the clutch is disengaged the driven shaft remains stationary. When the clutch is engaged, the operating forks merely lie in the groove *J* with ample clearance between them and the shoulder of the internal part of the clutch, so that there is no friction between the parts when the clutch is transmitting power. When, however, the forks



SECTIONAL PLAN: "PARSONS" PATENT CLUTCH.

are drawn over one another friction is set up on the two faces of the groove *J*, by reason of the fact that the clutch spring is acting against the forks, and this friction has the immediate effect of checking the further revolution of the part driven by the inner clutch member. Another point in the operating gear is that the first movement of the clutch fork disengages the clutch, but if the movement is continued until the lever is brought right over, the forks then pass each other beyond the wedge faces, and come to flat surfaces where there is no tendency for the said forks to return to their normal position, thus the clutch remains held out of engagement without the aid of any quadrant or catch. The angle of the wedges on the forks is such that the clutch lever can be released at any mid-position, leaving the clutch slipping if necessary without its gradually coming into gear.

The Cost of Hauling by Motor Wagon.—So few figures are available of the cost of hauling by motor wagon over an extended period that we make no apology for reproducing in full the report of Mr. G. H. Pickles, A.M.Inst.C.E., the borough engineer of Burnley, on the working of the Borough's "Coulthard" steam wagon over a period of three years, and which is specially interesting as showing how well some of the earlier types of vehicles have performed and still continue to perform :—

"To the Chairman and Members of the Highways and Sewage Committee.

"Gentlemen,—In accordance with your instructions, I have pleasure in submitting a statement showing the work done by the motor wagon during the three years it has been working, and also the cost of such work. The motor wagon is by Coulthard & Co., of Preston. It has been in use since June, 1902. It cost £600. The body of the vehicle is constructed of oak, ash, and elm. The frame of the vehicle is of channel steel 6 ins. by 2½ ins. by ⅜ in. The wheels are of the gun-carriage type, the front wheel tyres being 5 ins. wide, and the back wheel tyres 10½ ins. The motive power is a compound link reversing engine, having cylinders of 4 ins. and 7 ins. diameter, with a 6-in. stroke, and developing 30 h.-p. A double brake is fitted, acting on each hind wheel. The boiler is of the fire-tube type, and constructed to work at 200 lbs. pressure. The length over all is 19 ft. 6 ins., and the width over hubs 6 ft. 6 ins. The tare weight, exclusive of water and fuel, is 5 tons, and in full working order 6 tons. The internal measurement of the wagon is 12 ft. by 5 ft. by 1 ft. 6 ins., and when carrying sand or ashes the depth can be increased by side-boards to 2 ft. 6 ins. The load usually carried is from 4½ to 5 tons. The height of the wagon bottom from the ground is 3 ft. 6 ins.

"The work consists of hauling ashes, coke, and stone, or any material used in streets or roads. It is also found useful at times for shunting railway wagons on our private sidings at Dane's House Yard. The motor wagon is not easily got on to the new streets in process of formation, as it requires a good, hard, well-formed road. The district travelled is hilly, with a considerable proportion of macadamised roads. If the roads are at all slippery or greasy it is necessary to have a man in attendance, in addition to the driver, to throw gravel or some gritty substance under the wheels, and this has been so frequent that the motor wagon is never sent out now without the second man. This necessity for a second man might probably be largely obviated if some mechanical appliance were fixed to the motor enabling the driver, by using a foot lever, to scatter the grit substance under the wheels.

"A considerable item is that for repairs. At least £1 per working week is expended on repairs, and, in addition, the motor is laid up 10 per cent. of its time while such repairs are being carried out. It is also stopped about 7 per cent. of its time for cleaning. The driver is a fairly-skilled workman, and is able to do the ordinary repairs. He, however, assists in loading and unloading when not engaged with his engine. The motor wagon works nine hours per day and the driver 10 hours. It is stabled on Saturdays for cleaning. During the three years the journeys of the motor wagon have, as far as possible, been 1½ to two, and occasionally six, miles out from the depot (320 journeys of the latter distance being travelled). The cost of hauling one ton a mile by the motor wagon is 8·5*d*., as against 10·5*d*. with horses, assuming that a horse, cart, and driver be hired at 7*s*. 9*d*. per day of nine hours. This includes both the out and in journey, and the time for loading and unloading. We find that for long journeys the motor wagon is much more economical than horse haulage, but in short journeys it is considered of no advantage owing to the time taken up in loading.

"Appended is a statement of the work done and the cost of same during the three years, and I may point out that in making up the cost of haulage by the motor wagon I have allowed the sum of £96 10*s*. 6*d*. per annum for interest and sinking fund, the interest being at the rate of 3¼ per cent.,

with the repayment spread over seven years only :—

"*Work done by 'Coulthard' Motor Wagon, June, 1902, to June, 1905*; Hauling, 6,060 hours; shunting, 283 hours at 2*s.* 6*d.*; private work, 121 hours at 2*s.* 6*d.*; under repairs, 869 hours; under cleaning, 573 hours; not working, ground slippery, 204 hours; total tons carried, 11,258; total miles travelled, 10,250; total tons carried one mile, 23,157, at an average cost of 8·5*d.*

"THREE YEARS' COST.

	£	s.	d.
Repairs	140	0	0
Coke—12½ cwt. per week for 130 working weeks—at 6*d.* per cwt. ..	40	12	6
Oil bath for engine to run in.. ..	6	0	0
Oil for bearings—1 gallon per week at 1*s.* 3*d.*	8	2	6
Wages—1 man, 7,943 hours at 7*d.* ..	231	13	5
" 1 man, 6,478 hours at 6*d.* ..	161	19	0
Insurance..	6	0	0
Interest and sinking fund on £600 at 3½ per cent. for seven years ..	289	11	6
	883	18	11
Less shunting and private work	50	10	0
Cost of hauling 23,517 tons by motor wagon at 8·5*d.*..	833	8	11
Cost of hauling 23,517 tons by horses at 10·5*d.*	1,028	17	4
Being a saving by the motor wagon of	194	8	5

G. H. PICKLES, A.M.Inst.C.E.,
Borough Engineer."

A Two-Gallon Efficiency Trial.—A consumption trial recently undertaken by the Automobile Club of America has produced such extraordinary results that they cause one to pause and ponder. As its title indicates, each car was allowed two gallons of petrol, and the test was to get as far as possible with that allowance.

The published result is as follows:—

Car.	Horse-power.	Passengers.	Contest Weight.	Miles.	Order of Merit.
Franklin ...	12	2	2,300	87·00	1
Frayer-Miller ...	20	5	4,070	47·90	2
Darracq ...	20	5	3,910	46·44	3
Berliet	24	5	4,460	39·10	4
Mack	50	19	10,125	17·13	5
Franklin ...	12	4	2,940	58·40	6
Queen	28	4	3,960	41·40	7
Stoddart-Dayton	30	5	4,000	40·83	8
Lozier	40	6	5,290	30·28	9
Renault	14	5	4,200	36·61	10
Darracq ...	32	4	4,400	34·62	11
Compound ...	16	5	3,410	43·50	12
Frayer-Miller ...	24	5	4,200	35·50	13
Renault	10	4	4,040	36·83	14
Packard ...	24	6	4,910	30·25	15

The following is the formula employed in the trial: The rating is based on cars having four or more cylinders. Cars having two cylinders will be rated as though they weighed, loaded, 75 per cent. of their actual weight. Cars having one cylinder will be rated as though they weighed, loaded, 70 per cent. of their actual weight. The scores made in the contest will be arrived at as follows: To the actual weight of the car with messengers as weight at the moment of starting, or 75 per cent., or 70 per cent. of the same as mentioned above, a handicap of 800 pounds will be added. This sum will be multiplied by the distance in miles travelled to obtain the score. The cars making the highest, and the second and third highest, scores, will receive the first, second, and third prizes respectively.

This formula seems to have effectually excluded cars having single cylinders, as three ran greater distances than any of those classified above. The "Indian" tri-car ran 99·8 miles on one gallon, equal to 199.6 miles for two gallons. Two "Orient Buckboards" did respectively 98·8 and 93·8 miles on the two gallons.

It is interesting to note that the winning car, the "Franklin" (weighing 2,300 lbs.), which ran 87 miles on two gallons had a four-cylinder air-cooled engine.

A Gearless Motor Omnibus.—The Gearless Motor Omnibus Co. Ltd. will shortly place on the streets of London an omnibus in conformity with its title, and if the system employed develops no defects in practical use the noise, grating, and jarring which now herald the approach of a motor 'bus will become one of the disappearing sounds of the London streets. The vehicles to be employed are constructed on the "Auto-Mixte" system of Henri Pieper, of Liège. This system differs from earlier petrol-electric systems in several respects, notably by the absence of separate motors for transmission. The petrol motor employed, developing about 24 h.p., drives the armature of a dynamo, which generates current for a battery of 25 Tudor cells, each having a capacity of 60 ampere hours. In place of the usual clutch is a magnetic one which consists of a soft iron disc which is mounted on the armature shaft and revolves with it, whilst having a limited amount of longitudinal movement thereon. This disc rotates between two soft iron crown pieces, each wound to form an electro-magnet. One of these crown pieces is attached to the front end of the propellor shaft, which is in direct gearing with the differential back axle—no other gearing being employed—and the other crown piece is rigidly fixed to the side members of the frame. In its

normal condition the disc on the armature shaft lies midway between the two crown pieces out of contact with both. When the foot pedal is slightly depressed the crown piece on the propeller shaft is magnetised, which thus draws the disc on the armature shaft into contact with it, thus clutching the two shafts together. On further depressing the foot pedal the fixed crown piece is magnetised and the other crown piece de-magnetised, which draws the disc on the armature shaft into contact with the fixed crown piece, thereby forming a powerful brake which is said to be capable of pulling the vehicle up in its own length. The carburettor is of the float-feed type, and the throttle valve is controlled electrically by means of a solenoid which is so constructed and arranged that when the battery is below its normal voltage the throttle valve is full open so that the petrol motor works at full power and operates both to propel the vehicle and to charge the cells, and as soon as the accumulators are fully charged the throttle valve is partially closed, so that the engine only supplies power to drive the vehicle. To start the petrol engine the control lever is pushed slightly forward, which action connects the battery with the dynamo, which, operating as a motor, starts the petrol engine. As soon as the petrol engine attains a certain predetermined speed the electric ignition of the petrol engine is automatically switched on, and the engine then runs in the ordinary way, both propelling the vehicle and keeping the cells fully charged. When the load reaches a predetermined point—as when ascending a gradient—the battery is automatically switched on so that the dynamo acting as a motor assists the petrol engine. As the battery is designed to give out approximately 20 h.p. for one hour, it will be seen that if necessity arises over 40 h.p. can be obtained for that space of time. One great advantage of this system is that the petrol engine can be stopped in traffic, thereby saving wear and tear and eliminating noise and vibration.

The "Arroll-Johnston" Light Delivery Van.—The New Arrol-Johnston Car Co. Ltd. have recently put on the market a light parcels delivery van which has several characteristic features. In the first place the engine (12-15 h.-p.) is of the same type as that fitted to the car that won the International Tourist Trophy race last year. It has two balanced horizontal cylinders, and runs at 800 revolutions per minute. The forced air circulation for cooling the water in the radiator is obtained by means of a fan formed in one with the fly wheel. The ignition is by means of the "Arrol-Johnston" magneto. The governor is adjustable at will, enabling the speed to be varied from 250 to 1,200 revolutions per minute. A hand-throttle is also fitted. Forced lubrication of an automatic type is employed. The transmission is by cardan shaft with a spring drive, the clutch employed being the "Hele-Shaw" of a special design. The change speed gear gives four speeds forward and a reverse, the forward speeds permitting the vehicle to run up to 20 miles an hour with a maximum load of 30 cwt.

Locomotive and Railway Engineering.

Six-Coupled Express Passenger Engine: Caledonian Railway.—By the courtesy of Mr. T. F. McIntosh, locomotive superintendent of the Caledonian Railway, we are enabled to illustrate the new six-coupled locomotive, 903 class, designed by him for the Grampian Corridor Express Service introduced last year.

This engine generally follows the design of Nos. 49 and 50; that is to say, it is of the six-coupled type with inside cylinders, driving on to the front axle, with wheels 6 ft. 6 in. diameter and a four-wheeled leading bogie.

The connecting rod, however, has been increased from 6 ft. 8 in. to 7 ft. The cylinders are 1 in. smaller in diameter, the valve motion being practically identical, the slide valves being, as before, placed on the top of the cylinders.

No trouble has been spared in increasing the dimensions of the bearings, which are for the driving axle 9½ in. diameter by 10½ in. long, and for the intermediate and trailing, which are concave journals, 8 in. diameter in centre, 9½ in. diameter at the ends, and 12 in. long.

The big-end bearing has also been slightly increased, it now being 9½ in. diameter by 4¾ in. long, as against 4½ ins. in Nos. 49 and 50, for the purpose of, as far as possible, eliminating the possibility of heating.

Another variation of the previous standard design is the provision of ½ in. total side play on the trailing axle. This, of course, necessitates a knuckle joint in the trailing coupling rod.

A better distribution of the weight has also been obtained by substituting a built up steel plate drag-box in place of a cast-iron one, and also by substituting direct stays in the crown of the fire-box in place of the usual roof bars.

The diameter of the boiler has been increased from 5 ft. to 5 ft. 3½ in., so as to give a greater heating surface and steam capacity. The tubes are 2 in. external diameter throughout, and are of mild steel, galvanised.

The fire-box shell is 8 ft. 6 in. long by 4 ft. wide, and has a grate area of 26 sq. ft.

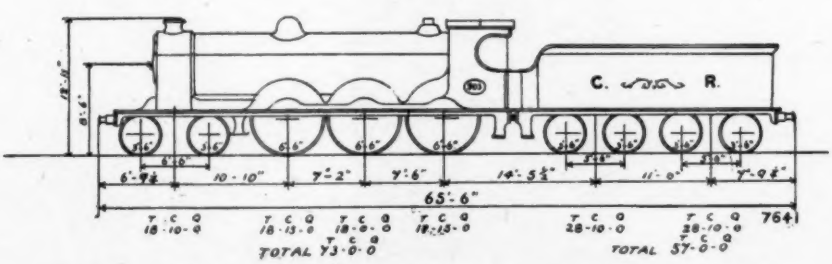
The safety valves are of the double type, having four valves 4 in. diameter, with independent springs, which are set for a working pressure of 200 lb. per sq. in. Sand boxes have been fitted to the driving and intermediate wheels.

The stuffing boxes of the valve spindle and piston rod have a patent metallic packing.

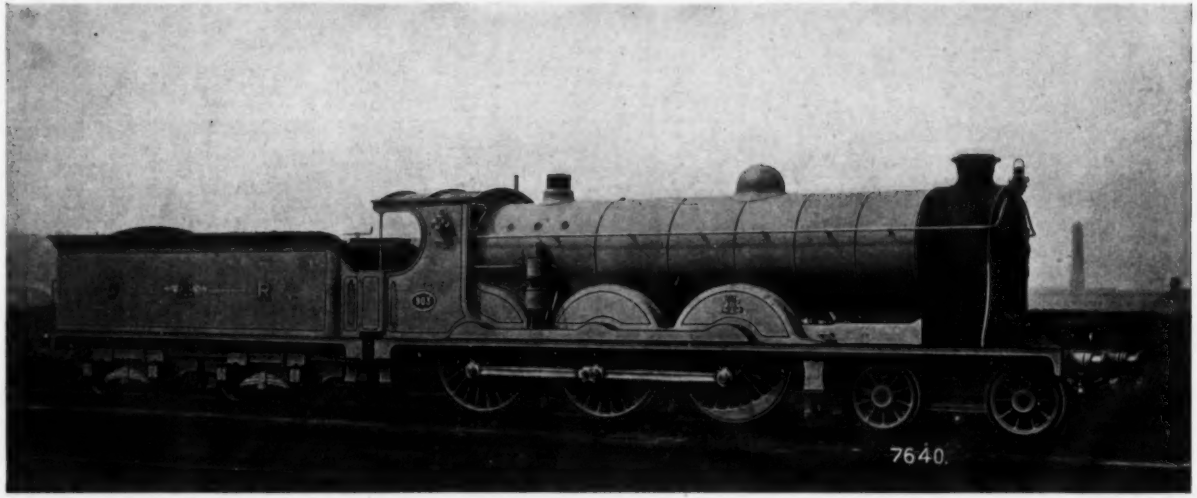
Under test, the boiler has shown improved steaming power, probably due to the substitution of the *direct* stays for roof bars in the crown of the fire-box, and also to an increased water space between the outer and inner fire-box shells.

The engine is equipped with the usual "Westinghouse" brake fittings, and has also an ejector and "through" pipes to enable it to work vacuum brake fitted trains when required.

The form of steam reversing gear used is the Caledonian standard pattern, which retains the use of the reversing lever and notch-plate.



6-COUPLED EXPRESS PASSENGER ENGINE: CALEDONIAN RAILWAY.



6-COUPLED EXPRESS PASSENGER ENGINE: CALEDONIAN RAILWAY.

The following are the principal dimensions, &c.:—

Cylinders :—

Diameter	1 ft. 8 in.	Stroke	2 ft. 2 in.

Wheels :—

Diameter on tread, bogie ..	3 ft. 6 in.	Diameter on tread, D, I, and T.	6 ft. 6 in.

Boiler :—

Height of centre from rails	8 ft. 6 in.	Diameter of barrel	5 ft. 3½ in.
Length of barrel	17 ft. 7⅞ in.	Thickness of barrel plates	¹¹⁄₁₆ in.

Firebox Shell :—

Length outside	8 ft. 6 in.	Depth from centre at back ..	3 ft. 9 in.
Breadth outside at bottom ..	4 ft.	Thickness of plates, sides ..	½ in.
Depth from centre at front ..	5 ft.	,, ,, crown ..	½ in.

Tubes (Steel) :—

External diameter	2 in.	Height of chimney above rail	12 ft. 11 in.
Distance between tube plates	16 ft. 8 in.		

Heating Surface :—

Fire-box	148·25 sq. ft.	Grate area	26 sq. ft.

Working Pressure, 200 lb. per sq. in.

Weight of Engine in Working Order, 73 tons.

Bogie Tender :—

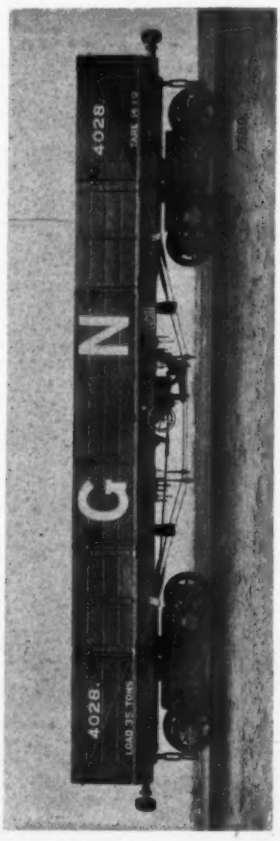
Capacity of tanks	5,000 galls.	Diameter of wheels	3 ft 6 in.
Fuel space	6 tons.	Weight of tender, full ..	57 tons.

Weight of Engine and Tender in Working Order, 130 tons.

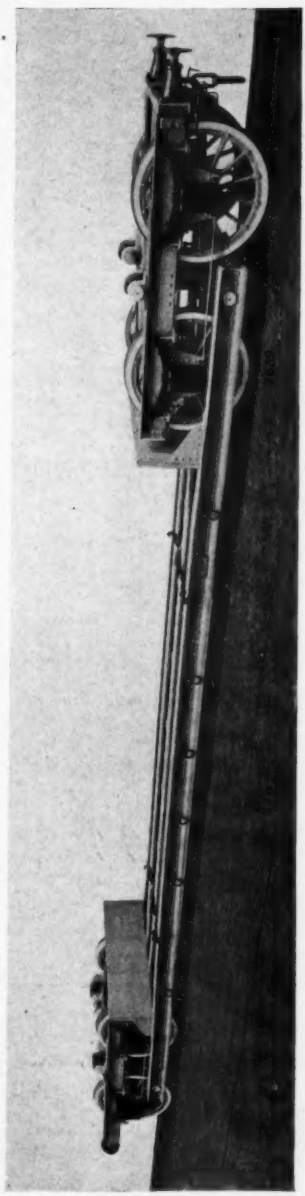
Swivelling Wagon : Great Northern Railway. — A wagon embodying some interesting features has recently been completed at the Doncaster Works of the Great Northern Railway to the design of Mr. Gresley, the assistant to Mr. Ivatt in charge of the carriage and wagon department. The wagon has a capacity of thirty-five tons, and is fitted with a bogie capable of swivelling right round when the check chains are off, so that it can be turned on an ordinary wagon turntable in two operations.

The wagon is really an experiment, and, so far, only one has been built.

40-Ton Bogie Well Wagon for the Cheshire Lines. — The accompanying illustration is that of a 40-ton well wagon recently constructed for the Cheshire Lines



SWIVELLING WAGON : GREAT NORTHERN RAILWAY.



40-TON WELL WAGON FOR THE CHESHIRE LINES COMMITTEE.

Committee by the Leeds Forge Co., and designed by Mr. J. G. Robinson, chief mechanical engineer on the Great Central Railway, for the conveyance of boilers, large castings and similar heavy loads. The wagon has a total length over buffers of 59 ft. 3 in., and a width over headstocks of 7 ft. 3 in. The wheels have a diameter on tread of 4 ft. 6 in.; the bogie wheelbase is 6 ft. 3 in., and the centres of bogies 44 ft. 9 in. apart. The journals, inside and outside the wheels, are 8 in. by 5½ in., and the centres of the journals are 6 ft. 4 in. apart. The distance from rail level to the floor of the wagon is 1 ft. 8½ in. The buffer height is 3 ft. 5½ in. from rails, and the centres of the buffers 5 ft. 8½ in. The well of the wagon has an inside length of 32 ft., and a width, over plates, of 7 ft. 5 in. The wagon is fitted with hand brake on one bogie only, applying one block to each of two wheels only. If loaded to its full length the wagon will take a load of 40 tons, and, when loaded within a central space of 12 ft. it will carry 25 tons.

Exhaust Steam Injectors for Locomotives. — On a previous occasion* we devoted considerable space to the high-pressure locomotive injector manufactured by Messrs Davies and Metcalf, which, as many of our readers are aware, has been adopted on the leading railways at the present time. These injectors, improved in respect of several details, have recently been fitted to the new "Atlantic" type engines of the London, Brighton and South Coast Railway. The principle feature of the apparatus is the flap nozzle, a very ingenious form of combining nozzle, details of which are given in Fig. 1.

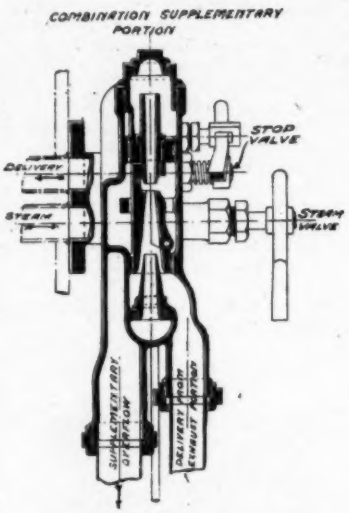


FIG. 2.

As will be seen, the combining cone is split longitudinally at its middle section, up to a point near the steam nozzle, where the cross-section of the cone is sufficient to permit a large and easy exit for the water or steam, the loose flap being hinged.

The force of the steam, striking against the hinged portion, opens it, exposing a large area of discharge, and so enabling the steam to discharge freely into the overflow pipe. As soon as the water is admitted and meets the steam, a partial vacuum is formed; owing to the condensation of the steam, the hinged flap closes and is held in that position so long as the jet is continuous. If the continuity of the jet is broken in any way, then the pressure of the steam pushes open the hinged flap, and a free discharge is offered, until a vacuum is again formed and the continuity of the jet re-established. The action of the exhaust injector is assisted by a very small diameter nozzle known as the inducer nozzle, and is fixed concentrically with it. Live steam is supplied to

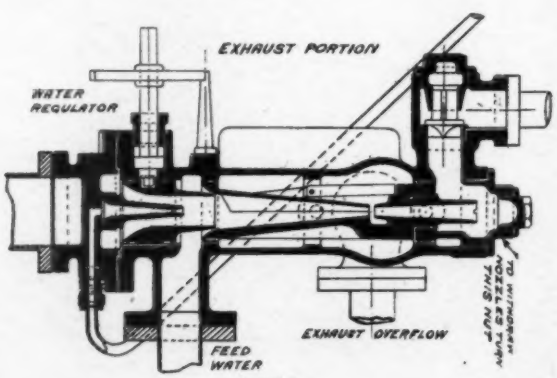


FIG. 1.

* Vol. ix., p. 422.

the inducer nozzle with the object of creating a vacuum in the exhaust nozzle, thus inducing a greater flow of exhaust steam from the blast pipe to the injector.

The injector itself consists of two parts known as the exhaust portion (Fig. 1) and the supplementary portion (Fig. 2), these two portions being connected by a pipe, the exhaust portion delivering into the supplementary portion.

The latter is simply a small live steam injector specially designed for handling extremely hot water. It is capable of working up to over 300 lbs. pressure, receiving feed water at a temperature of 170° F. to 190° F. from the exhaust portion, and delivering its water to the boiler at a temperature of 280° F. An essential feature of the apparatus is the grease separator and steam drier (Fig. 3), the function of which is to remove from the exhaust steam, grease, dirt or condensed steam, which may have been carried over. The steam entering the casing strikes against the baffle plates, which deflect the suspended matter into the well below, whence they are discharged into a drain pipe, through the automatic drip valve. The steam then passes through a perforated metal cylinder which is covered by a sleeve made of absorbent towelling which further dries it and removes any impurities remaining.

The economy resulting from the use of this exhaust injector will be understood from the following.

The exhaust steam leaving the blast pipe at a temperature of 212° F., and flowing through the exhaust nozzle, meets the feed water at a temperature of say 50° F. Condensation immediately takes place, and a vacuum is formed, the combined jet of water and steam rushes forward, through the combining nozzle, and into the delivery nozzle, and leaves the exhaust portion at a temperature of about 180° F. and a pressure of 70 lbs. The feed water is thus heated from 50° F. to 180° F., an increase of temperature of 130° F. The water is now delivered into the supplementary portion of the apparatus, where it is met by a jet of live steam, which further heats it to a temperature of 280° F. and gives it sufficient pressure to force it into the boiler.

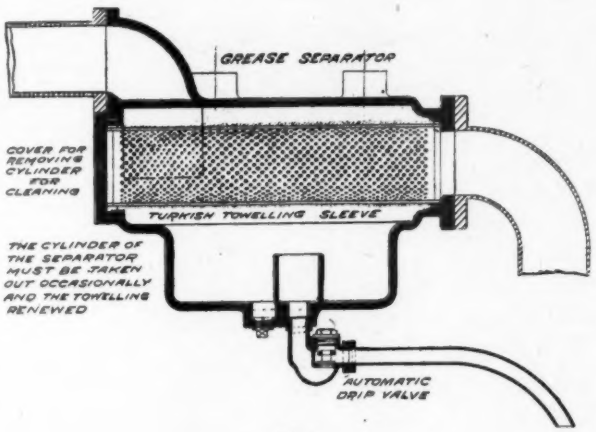

GREASE SEPARATOR
COVER FOR REMOVING CYLINDER FOR CLEANING
TURKISH TOWELLING SLEEVE
THE CYLINDER OF THE SEPARATOR MUST BE TAKEN OUT OCCASIONALLY AND THE TOWELLING RENEWED
AUTOMATIC DRIP VALVE

FIG. 3.

The advantages attendant upon introducing feed water at a temperature near that of the boiler itself are obvious.

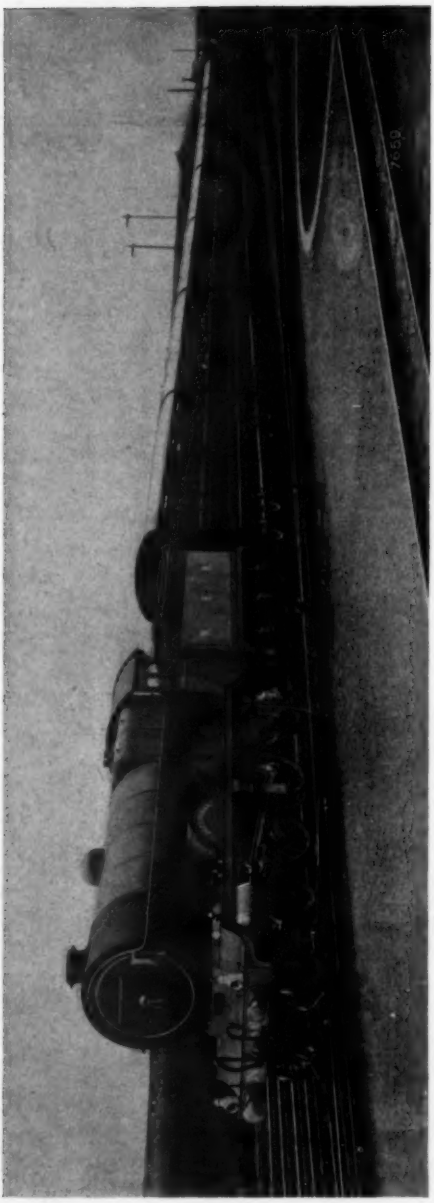
Trains *de luxe* on the North British Railway.—The North British Railway Company are about to introduce a series of powerful locomotives of the "Atlantic" type for hauling their heavy express trains, particularly over the East Coast and Waverley routes and the Aberdeen main line. Fourteen of these locomotives, to the design of Mr. W. P. Reid, Locomotive Superintendent, are being built by the North British Locomotive Company, Ltd., Hyde Park Works. Their principal dimensions are as follows:—

Cylinders	Diameter...	1 ft. 8 in.
,, ...	Stroke ...	2 ft. 4 in.
Coupled wheels	Diameter...	6 ft. 9 in.
Trailing wheels	,, ...	4 ft. 3 in.
Bogie wheels	,, ...	3 ft. 6 in.
Boiler pressure	200 lbs per sq. in.	
Weight of engine in working order...74 tons 8 cwt.		

Principal particulars of tenders:—

Capacity of tank	4,240 gallons.
Fuel space	7 tons.
Diameter of wheels	4 ft.
Weight of tender (full) ...	45 tons 8 cwt.

The boiler is built entirely of steel of the highest quality, and the fire-box plates are all of the best quality copper, the tubes being of steel. Combination injectors are fitted on the boiler and asbestos packed water-gauge cocks fitted with protectors to prevent injury to the men from a broken



NEW ATLANTIC LOCOMOTIVE AND BLOCK TRAIN FOR THE EDINBURGH-ABERDEEN SERVICE, NORTH BRITISH RAILWAY.

gauge glass. The engine is fitted with piston valves of the Smith pattern (with collapsible segmental rings) placed inside the frames, and the cylinders have asbestos packed water relief cocks. Automatic air and vacuum-destroying valves are fitted to the cylinders with a lubricator attached, which admits steam and oil to the cylinders when the engine is running down hill with the regulator shut. The engine is fitted both with the "Westinghouse" brake and vacuum ejectors, so that the engine may work a train of either "Westinghouse" or vacuum-fitted vehicles. It is also fitted with steam reversing gear, and has a reversing handle which can be fitted in a short time if anything should happen to the steam gear. Air sanding gear is provided for both coupled wheels, and the sand being delivered at the rail under pressure. A steam cock and reducing-valve are provided for carriage heating, the reducing-valve, which is fitted on the tender, permitting low pressure through to the carriages. The cab is roomy and well ventilated, having side windows and a roof ventilator. The tender is carried on six wheels, and is of the standard N.B. type. A special water-gauge is fitted, which shows the height of water in the tank.

Carriages. — The company have constructed two trains at their Cowlairs Works for the Glasgow and Edinburgh connection with Aberdeen. The trains are of the most modern type, having every convenience and comfort. Each train will consist of two portions, that from Glasgow will be composed of one composite, one third-class carriage, and one brake van, and that from Edinburgh of one composite and two third-class carriages and one brake van. The two portions will join at Dalmeny. The carriages are all built on four-wheeled bogies with pressed steel frames. The bodies are carried on special bearing blocks, fitted to minimise vibration and shock when running, and the floors are double and filled with material to deaden noise. The train is fitted throughout with electric light. In the first-class carriages the globes are not placed in a cluster as is usual, but on the compartment side, two separate globes being on the roof nearly over the seats, and

on the corridor side, a two-branched electrolier is placed on the corridor screen, thus diffusing the light equally over the carriage. A magnetic switch is in the van, which gives the guard partial control over the lighting of the train. In the third-class compartments two lights are distributed over the roof. The corridors and lavatories are lit by individual bulbs distributed over the length. The train is heated throughout with steam, which can be regulated by the passengers.

The lavatories, two of which are in each carriage, are provided with hot and cold water, the hot water being available in winter only. Vestibules are fitted on each carriage, which permit the passengers to walk from end to end of the train.

The composite and third-class carriages are 58 ft. 4 in. long and 8 ft. 6 ins. wide. The corridors are 2 ft. wide. The vans are 49 ft. 8½ ins. long and 8 ft. 6 ins. wide. The corridors throughout are covered with "Kork" matting, and the first-class compartment floors with linoleum, supplemented with rugs of a special design. The panelling of the first-class compartments are of quartered oak, polished and moulded, and the roof of Alhambrine, delicately relieved with gold.

The third-class compartments are upholstered in a manner similar to the first-class, but with a different pattern. The sides and back above the upholstery are of decorated Alhambrine. The internal finish in the third-class compartment is of oak.

The lifting windows are fitted with special draught excluders, and ventilation is obtained by roof ventilators, which can be operated by the passenger. The corridor doors slide on roller bearings, and are fitted with draught excluders. Specially large nets are provided above the seats, capable of carrying larger packages than usual. The train is equipped throughout with the "Westinghouse" air brake. The carriage roofs are elliptic in shape and are much more spacious than the present type of carriage. The painting of the carriage outside is the usual crimson lake, picked out with gold lines.

The company have just put on traffic ten new goods locomotives of a more powerful type than hitherto. They were built by the North British Locomotive Co., Ltd., Atlas Works, to the design of Mr. W. P. Reid, Locomotive Superintendent. The cylinders are 18½ ins. diameter by 26 ins. stroke, and wheels are 6-coupled 5 ft. diameter. The engines are fitted with piston valves of the "Smith" pattern, which have been found so satisfactory on some of the earlier engines, and the boiler pressure is 180 lbs. per sq. in.

In addition to having under construction at Cowlairs Works a large number of wagons of different types and dimensions, the company have arranged to place upon the line early 2,687 new wagons and vans, comprising 2,100 mineral wagons, 200 bar-iron wagons, 375 covered goods vans and twelve hopper wagons. The contracts have been divided among the following firms:—

Messrs. Hurst, Nelson & Co., Ltd., Motherwell.

Messrs. S. J. Clay, Ltd., Long Eaton.

Messrs. The Motherwell Wagon and Rolling Stock Co., Ltd.

Messrs. R. Y. Pickering & Co., Ltd., Wishaw.

Messrs. W. R. Renshaw & Co., Ltd., Stoke-on-Trent.

Delivery under the contracts is expected to begin in September, and the whole to be delivered by January, 1907.

There is considerable activity at Cowlairs Works just now, not only in the carriage and wagon departments as already indicated, but also in the engine erecting departments, where goods engines, similar to those contracted for outside, and intermediate engines for fast goods and excursion train-working are being built.

Electrical Notes.

By ANDREW STEWART, A.M.I.E.E.

Electric Haulage on the Teltow Canal.—In our February issue we dealt at some length with electric canal haulage in general, and the Erie Canal in particular. The Teltow Canal, which is now handling a considerable volume of traffic, has not only a system of electric haulage, but the only lock in its entire length is electrically operated,

The canal is 22½ miles long, and connects the Havel, near Potsdam, with the Spree, above Berlin. It therefore passes through the large agricultural district south of Berlin, though no doubt this district will become more industrial than hitherto, as the canal puts it in communication with the Oder and the Elbe.

The generating station, which is owned by the Teltow District Council, contains two "Zoelly" steam turbines, each of 1,000 h.-p., driving a 6,000-volt three-phase 50-cycle generator and a direct current generator. The latter gives current at 550 volts, which operates the section of the canal in the immediate neigbourhood of the power-station. The high-pressure three-phase current is converted to direct current at 550 volts, by rotatory converters at sub-stations located close to the canal. The canal bank is lighted at some places with electric light, and the generating station also supplies public lighting, and electric tramways.

The tractors are similar to a type tried in the United States some time ago. One is illustrated (Fig. 1). There are two overhead trolley wires, a lead and a return, which are divided up into sections about 1,000 yards in length.

As will be seen from the illustration, the tractor has a four-wheel truck about the middle, and at the trailing end there is a

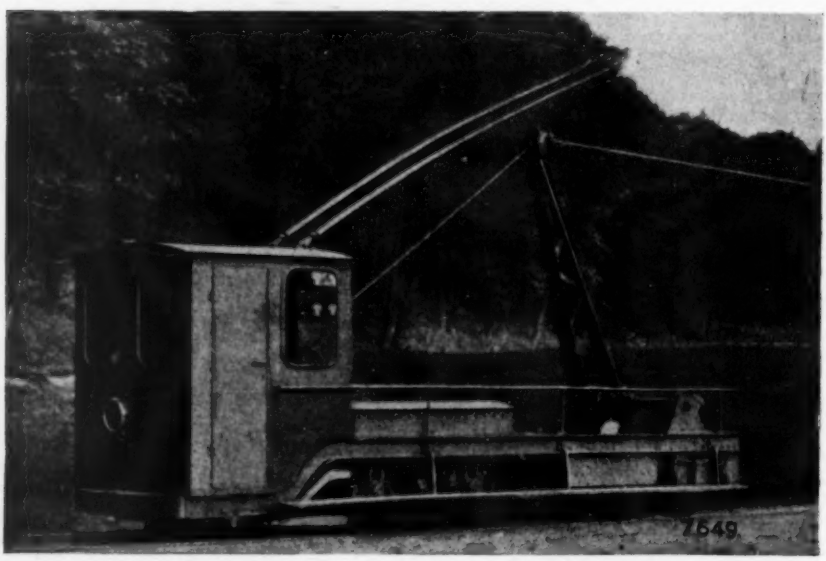


FIG. 1.—ELECTRIC HAULAGE ON THE TELTOW CANAL: VIEW OF TRACTOR.

pony axle. This truck has two 10 h.-p. motors. The mast over which the towing rope passes is 8 ft. long, and it may be adjusted to any angle in order to enable the tow rope to clear other barges which may be alongside the canal bank. The tow rope is attached to a drum in the cab, which is operated by a 1 h.-p. electric motor, so that the barges can be moved by winding up the rope instead of by the motion of the tractor, a useful arrangement when docking, or at locks. Moreover, this drum has a friction clutch, which allows the line to pay out should the tractive resistance of the barges become excessive.

In order to prevent the tractor being overturned by the pull of the tow rope on the mast at its maximum elevation, the bulk of the locomotive's weight, about 60 per cent., is placed on the landward pair of wheels. The mast is also placed out of the centre of the tractor towards the landward side.

The only lock embodies not a few important features. Single gates raised and lowered in a perpendicular direction have been substituted for the V shaped gates which are usual. These gates are counterweighted to render them easy of operation. The gates rise clear of the water, and the time taken to lift the gate a height of 27 ft., which is the maximum, is one minute. The lock master signals to an operator in an elevated cabin the nature of the movements required, and as all the motors are controlled by solenoid starters, the operator merely presses a button, the actual starting and stopping being done automatically. The handling of the barges into and out of the lock, is by means of overhead electric travellers, which tow them when they have been cast off from the tractor. An electric capstan further facilitates movements in the lock. There are two chambers to the lock, and the arrangements are such that when one is full another is empty. The water in one flows into the other until it is half full, the remainder being supplied from the head. This economises water, which is often important.

Four 600-ton barges, two up and two down, can be handled in half-an-hour; and assuming that the average tonnage of the barges using the lock is 400 tons, the lock can handle 32,000 tons in a ten hour day. The most usual towing speed on the canal is $2\frac{1}{2}$ to $2\frac{3}{4}$ miles per hour, though over 3 miles per hour is reached by the new tractors. The power increases so rapidly at higher speeds, due, probably, to wave friction, that the higher figure mentioned is looked upon as the maximum economical speed. The tractor can haul two 600 ton barges at this speed. The tractors described are the latest type used on this canal. The earlier tractors only had 8 h.-p. motors, and hauled their load at the slower speed mentioned.

The Electrification of the Great Western Railway Suburban Lines.—The electrification of the Metropolitan Railway rendered necessary some measure of electrification on the part of the Great Western Railway Company, who run trains from Aldgate to Hammersmith, Westbourne Park, and Uxbridge Road. The electrification, so far as the line equipment and rolling stock goes, presents no important features, being in all respects duplicates of the now well-known Metropolitan equipment, but the electrical equipment of the sub-stations calls for some special notice, for instead of rotatory converters, cascade converters of the "Peebles-La Cour" type are employed.

The generating plant at Park Royal consists of eight 750 kilowatt three-phase generators giving a pressure of 6,600 volts at a periodicity of 50 cycles. These generators are built by the Electric Construction Co., and direct coupled to "Belliss" and "Morcom" triple expansion engines running at 250 revolutions per minute. There are the usual steam and motor-driven exciters. The auxiliary machinery is driven by an independently generated three-phase current, so that the coal handling, stoking, &c., is independent of the main generating plant. There are ten Babcock-Wilcox boilers with chain grate stokers; coal for these is discharged from wagons having bottom doors into hoppers, from which it is conveyed by two tray conveyors to the foot of two bucket elevators, which raise the coal to a height of 50 ft. above the boiler house floor level. From these it passes into two more conveyors, which distribute the coal in the bunkers, from which it passes to the measuring hoppers and stokers. The high-pressure three-phase current is converted to direct current at three sub-stations. These sub-stations are equipped with the cascade converters already mentioned, there being seven 400 kilowatt (540 h.-p.) sets at Shepherds Bush, four 400 and two 200 kilowatt sets at Royal Oak, and one 400 and two 200 killowatt sets at Old Oak Common sub-station. In addition, there are at Shepherds Bush and Royal Oak two large buffer batteries working in parallel with the motor converters. The former has a battery of the "Tudor" type, having a capacity of 1,680 amperes for one

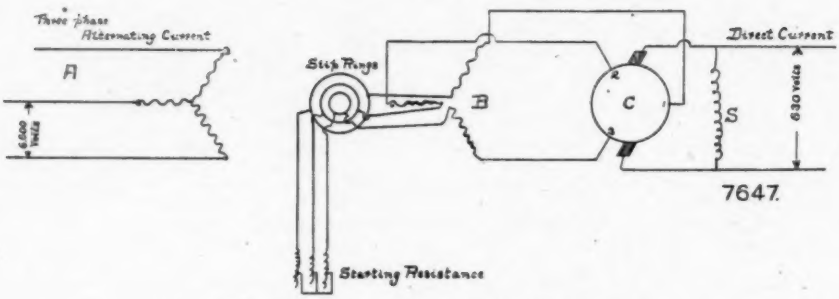


FIG. 2.—DIAGRAM OF CONNECTIONS: CASCADE CONVERTER.

hour, about 1,400 h.-p. for one hour, and the latter a battery with a capacity of 840 amperes for one hour. Each battery has a "Highfield" reversible booster, and they are intended for taking the peaks of the load when the trains are starting, and keeping a reasonable load on the motor generators when the sections which they feed are lightly loaded. Thus the maximum load on the sub-stations and feeders is never very much in excess of the average.

The cascade converters which are employed throughout are interesting, inasmuch as there are not yet many in use in this country, though their use has been fairly common on the Continent for some time. They have the commercial advantage that while not much, if any, more costly than rotary converters, they give all the advantages of motor generators. The connections are shown, Fig. 2, the three-phase supply current going to the stator of the polyphase induction motor A. This motor has a wound rotor B., to which is connected the slip rings and starting resistance shown. Up to this point the machine is merely an ordinary induction motor with slip rings, and it can be started as such from the alternating current side without difficulty. From the rotor winding, connections are taken as shown, to the direct current armature of the generator C, just as the connections on an ordinary converter.

The peculiarity about a machine connected like this is that half of the power supplied to the high tension alternating current side is transmitted through the shaft, and drives the direct current machine, just like an ordinary motor generator. The other half is transformed, depending upon the ratio of stator and rotor windings, and passes to the direct current side through the connections shown, as low-pressure alternating current. It is then converted, just as in a rotatory converter, into direct current. Such a cascade converter is therefore neither a motor generator nor a rotatory converter, yet it does what both do. Its great advantage is that, unlike an induction motor generator, it can be operated with a power factor at, or near, unity, and variations of the direct current E.M.F. can be obtained without reducing the power factor to any extent. No transformers are necessary on the high tension side, and it can be started easily either from the direct or alternate current side, the rotatory converter requires transformers, and must be started from the direct current side.

Another feature is that while the speed of a rotatory converter or induction motor is found from the formula

$$\frac{\text{supply periodicity} \times 120}{\text{number of motor poles}},$$

the denominator is, in the case of these cascade converters, the sum of the motor and generator poles. It is this characteristic which led to the combination being described as a cascade converter, for it is exactly similar to two ordinary induction motors in cascade.

Combination Petrol-Electric Road Vehicles.—In our issue of November, 1905, we illustrated and described a petrol-electric automobile; since that date there has been considerable development in this direction, especially in the case of motor omnibuses; indeed there are now several running in Paris, and there will shortly be some on the London streets. Unlike the petrol electric railway car, which we have previously noticed, no battery is carried, though in several cases the omnibus is electrically lighted from a small accumulator; this, however, is not used in connection with the propulsion of the omnibus, though

a small accumulator is sometimes used for exciting the dynamo field winding. The omnibuses of this type made by Messrs. Kreiger & Co. have a 24 h.-p. petrol engine direct coupled to a six-pole generator, the combination running at a maximum of 1,200 revolutions per minute; the field excitation is effected by three different methods, (*a*) the usual shunt winding from the brushes of the machine; (*b*) a shunt winding, current in which is supplied from a small battery; (*c*) a series winding, current in this flows so as to weaken the other two. The field is thus differentially excited, the case the pressure of the generator is nearly constant, and the energy output is not limited as in the case of the Kreiger bus. Only one motor is used to drive the back wheels, but this has two commutators, and a double wound armature, hence series-parallel control, with its advantages of large starting torque with moderate current, is obtained.

A petrol-electric omnibus controlled almost exactly as described in these notes in November last, will shortly be placed on the London streets, the only difference being that a battery of accumulators will be fitted

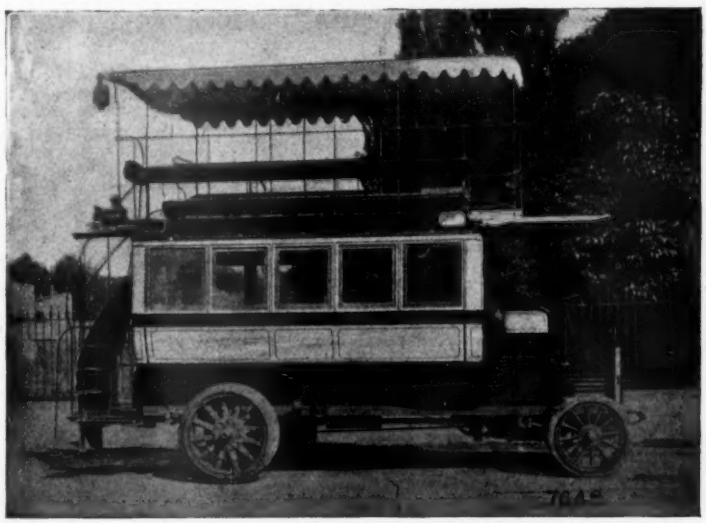


FIG. 3.—"DE DION PETROL-ELECTRIC OMNIBUS.

effect being that at heavy loads the series field tends to reduce the flux through the armature, and thus lower the effective E.M.F. of the generator, the product of current and E.M.F., *i.e.*, the actual horse power output. tends to remain constant over a wide range of speed, though as will be apparent, the pressure varies between wide limits. The motors, of which there are two, are geared to the rear wheels, they are compound wound,

The De Dion-Bouton Company make a somewhat similar omnibus (Fig. 3). The petrol motor is of 30 h.-p, running at 1,400 revolutions per minute, direct connected to a compound generator; in this to give the heavy current required for rapid acceleration, this battery being charged when the 'bus is slowing down or at rest. This system of control is sometimes described as the Auto-Mixte system.*

Electric Winding Plants.—Interest in electric winding has been stimulated by the very thorough discussion which has taken place on the relative merits of steam and electric winding. It appears that such winding plants employing the "Ilgner" system are being very rapidly installed both in this country and abroad. Moreover in winding

* Cf. p. 129.

from great depths there have been several notable installations—one in Austria will wind from a depth of 1,150 yards with a winding speed of 45 ft. per second, not a very high speed, considering that the electric winder at Zollern II. mine will shortly be increased to 66 ft. per second in order to maintain the output at the greater depth of the shaft, which is being increased from 306 yards to 545 yards. The winding drum at the Austrian mine already mentioned is 16½ ft. in diameter. The Heinrich pit at Pelkum, has an electric winder raising 1,400 tons per eight hours, from a depth of 820 yards, this will subsequently be increased to 1,000 yards: the weight of coal per wind is 5½ tons and the winding speed is 59 ft. per second.

In this country, Messrs. Siemens Bros. are erecting an electric winder at the Duffryn Rhondda Colliery, the winding speed in this case being 50 ft. per second and the weight per wind four tons, the depth of shaft at present is 520 yards, increasing later to 666 yards. A smaller winder is being supplied to the Priestman Collieries, Newcastle-on-Tyne; the depth is 83 yards and the speed only 8 ft. per second.

Apropos the question of electric winding, we have received from Dr. Herzfeld, of The Electrical Company, a communication relating to the observations in our May issue, *re* the controversy between Mr. Mountain and Mr. Hooghwinkel. Dr. Herzfeld does not question the general accuracy of our conclusions, but points out that our remark as to the inefficiency of the electric winding installation at the Grand Hornu mines was not justified. At the time of writing our notes for May, we had nothing but the figures of Mr. Mountain to guide us, and judged by these that the winding plant in question was inefficient. From the figures now supplied to us we find that the energy taken by a 125 h.-p. pump motor, two 200 h.-p. ventilators, and an electric locomotive, were debited against the winder, thus introducing a serious error into Mr. Mountain's figures, and making the performance of the winder appear decidedly inefficient. As we did not use these figures in the examples we quoted, the fact of a mistake having been made by the author of one of the papers, in no way vitiates the conclusions we then reached, viz., that the economy of electric winding is largely determined by the relative value of fuel at the pit's mouth; nevertheless we draw the attention of our readers to the matter, because it might appear from our remarks on the Grand Hornu installation that it is less efficient than Dr. Herzfeld's figures indicate.

Engineering Progress.

A new Oil-Engine Governor.—One of the novelties exhibited for the first time on the stand of Messrs. J. B. Petter & Sons, Ltd., Yeovil, at the Royal Agricultural Show at Derby, was an 8 b.h.-p. oil engine fitted with a governor of new design and which is illustrated herewith.

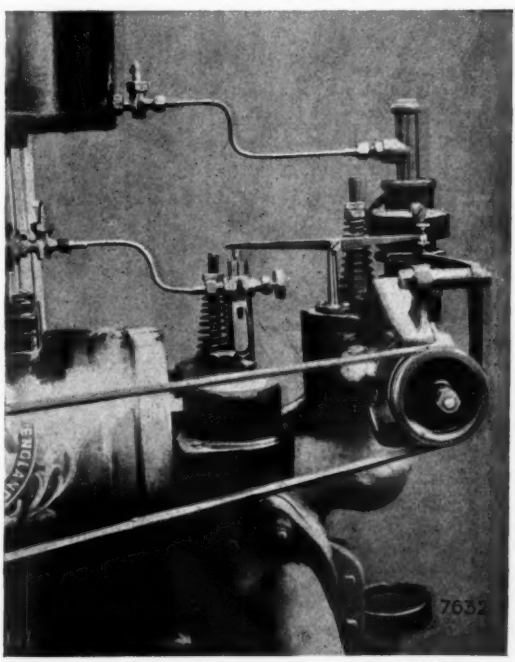
It has been well known for some time that the injection of water into the cylinder of internal combustion engines, and especially of an oil engine when working on medium or full load, has a very beneficial effect in preventing the premature ignition of the charge, but great difficulties have arisen in practice as to the best method of injecting the water.

To overcome these difficulties is the object of the new governor, which automatically opens the water valve when the engine is working on such a load as to require the admission of water, and both the time at which the water valve is opened and the quantity of water admitted are capable of the most accurate adjustment.

The object of the water is to regulate the moment of firing the explosive mixture, preventing premature ignition when the engine is heavily loaded, and also giving a more gradual and effective explosion. Great economy of oil consumption is found in practice to result, and it is found that the water has the effect of keeping the cylinder clean and free from carbon deposit.

The governor also provides a means of regulating the supply of the three constituents of the explosive mixture in an oil or spirit engine; viz. oil (or spirit), air and water respectively by means of three valves of different design which are all under the control of an ordinary centrifugal ball governor and governor lever. The result obtained is that the intensity of the explosion is proportioned to every variation of the load on the engine, and a much more regular turning moment is secured than is possible when governing on the "hit and miss" system, in which full explosions alternate with cutting out of the oil constituent of the explosive mixture, and other forms of proportionate governing, in which one constituent only, for example, the oil is proportioned to the load.

The Electrical Production of Nitrates.—During the past month the Faraday Society were honoured with the presence of Professor Kr. Birkeland, who read an interesting paper dealing principally with recent developments of the "Birkeland-Eyde" process for the fixation of atmospheric nitrogen as carried out in the nitrate manufactory at Notodden and at the experimental works at Arendal.



NEW PATENT GOVERNOR FOR OIL ENGINES

This particular process has already formed the subject of articles in THE ENGINEERING REVIEW,* but much additional information is given in Prof. Birkeland's paper.

By way of introduction extracts are given from the Presidential address delivered before the British Association in 1898 by Sir William Crookes, showing the urgent importance of the subject in consideration of the rapid rate of exhaustion of the world's present stock of fixed nitrogen—the great fertiliser for wheat—and it is pointed out that out of the air over each square mile of the earth's surface more saltpetre can be made than is to be found in the whole of Chili. A brief history of the oxidation of nitration by means of electricity includes references to the pioneering work of Priestley and Cavendish (about 1780), to the more recent work of Spottiswoode and Dewar (1880), Crookes (1892), and Rayleigh and Ramsay (1897), and finally to the technical applications developed by Bradley and Lovejoy (1903), and by Kowalski and Moscicki (1904).

The essence of the electrical side of the problem consists in the production of a stable and practical form of high-tension arc in which to effect the oxidation.

When two pointed copper electrodes, attached to a high-tension alternator, are placed equatorially between the poles of a powerful electromagnet, in such a way that the terminals of the electrodes are in the middle of the magnetic field, a circular disc flame will be formed which may be explained as follows:—At the terminals of the closely adjacent electrodes, a short arc is started, and under the influence of the field moves in a direction perpendicular to the lines of force, at first with an enormous velocity, which subsequently diminishes; and the extremities of the arc run back from the terminals of the electrodes. As the length of the arc increases, its electric resistance also increases, so that the tension is heightened until it becomes sufficient to create a new arc at the points of the electrodes. The resistance of this short arc is very small, and the tension of the electrodes therefore sinks suddenly, with the consequence that the outer long arc is extinguished. It is assumed that while this is taking place, the strength of the current is regulated by an inductive resistance in series with the flame. With an alternating current all the arcs with a positive direction of current spread out one way, while all with a negative direction spread in the opposite direction (the magnetising being effected by direct currents), and in this way, a complete, luminous, circular disc is presented to the eye. (Investigation with an oscillograph shows that if the field be made strong enough one may have, as indicated above, several positive arcs in succession, followed by the same number of negative arcs, but the best results are obtained when the field is such that there is only one arc per half cycle. In this case the oscillograph curves of e.m.f. and current are simply exaggerations of the well-known forms obtained by connecting across an alternating current arc lamp.) The working potential employed at Notodden is 5,000 volts, the current is an alternating current of 50 periods per second, and the terminals of the electrodes are at a fixed distance of about 8 mm. from one another. The cooling of the copper tube electrodes with water takes away about 7·5 per cent. of the electric energy discharged between the electrodes.

The alternating current disc-arc is enclosed in a furnace chamber lined with fire-brick, and provided with a metal casing. The fire-chamber of the furnace is narrow, in the direction of the lines of force from 5 to 15 cm. wide, and air is conveyed to the disc-flame, in an evenly-distributed supply through its walls. The system of magnets is composed of two powerful electromagnets, their extremities turned in towards the fire-chamber. The magnetic circuit is closed either as in a horse-shoe magnet, or through the shield-like, cast-steel casing of the furnace. The air is driven into the central region on both sides of the flame by gentle pressure from a Root's blower; and after passing in a radial direction arrives at a peripheral channel, whence it is conducted away. The horizontal electrodes are made of copper tubing, 15 mm. in diameter, whose terminals are within about 1 cm. of one another, and are cooled by water in circulation, which keeps them from fusing. The electrodes are exchanged and repaired after being in use for about three hundred hours, the exchange itself taking about fifteen minutes to accomplish. Such a furnace costs about £1,000 with its induction regulator but without the alternator. At the Notodden Saltpetre Manufactory there are three such furnaces in constant activity, each employing 500 kilowatts. These furnaces run with a great degree of steadiness, although the electrodes have no automatic regulation. A diagram is given in the original paper of a "Birkeland-Eyde" furnace. It is not one of the Notodden furnaces, but an earlier type, and is chosen because the arrangement of the air passages being less complicated than in later patterns it is more easily understood without lettering and detailed explanation. The principle is of course precisely the same.

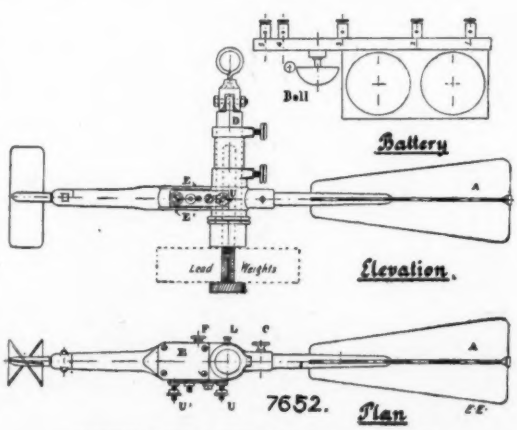
The air (containing nitrogen oxides) comes from the furnaces at a temperature of 600° to 700° C., and first passes through a steam boiler, the steam of which is employed in the further manufacture of the ultimate product, calcium nitrate. In the saltpetre manufactory now in course of erection, the gases will be conducted directly through the evaporating tank, an arrangement which implies such an important saving of heat, that the employment of coal may probably be avoided altogether. After the gases have passed the steam boiler, their temperature is reduced to 200°, they are conducted through a cooling apparatus to be further cooled to about 50°, and then enter two large oxidation chambers with acid-proof lining. Here further

* Vol. viv., pp. 212, 321.

oxidation takes place spontaneously, the compound formed in the furnaces (nitric oxide) becoming nitric peroxide, which is then conducted farther into an absorption system, where the gas is converted into nitric acid. The absorption system consists of two series of towers, whose internal dimensions are $2 \times 2 \times 10$ metres, each series containing five towers, two of granite and two of sandstone, filled with pieces of quartz, over which water, and the nitric acid formed, are made to trickle, while the fifth tower in each series is filled with ordinary bricks, over which trickles milk of lime. The milk of lime quickly absorbs the rarefied nitrous gases remaining, and is converted into a compound of calcium nitrate and calcium nitrite, which in turn is completely oxidised to nitrate by means of nitric acid. This nitrate lye, mixed with the bulk of nitric acid, reacts on limestone, and is converted into a solution of neutral calcium nitrate which may be crystallised out either in the normal or basic form. The yield of the furnaces is given as 500 kilogrammes of anhydrous nitric acid per kilowatt-year, but this is a minimum yield. The inclusive cost of production is stated to be £4 a ton, the selling price being £8 a ton; at Notodden about 25*s.* per E.H.P.-year is paid for power, but the cost is less than half of that.

The author finally discusses the theory of the oxidation of nitrogen in electric arcs, and incidentally he describes experiments made to determine the thickness of the arc threads. According to the simple thermo-chemical theory at every temperature a definite amount of NO is in equilibrium with a fixed mixture of air and nitrogen; at 3,000° C., for example, an entire 5 per cent. will be nitric oxide. To retain this quantity at a lower temperature the cooling must take place with very great rapidity. The great difficulty in making theoretical calculations is that of knowing the temperature of the arc. The author compares results obtained during a very careful trial run at Arendal with those calculated from Nernst's formula, assuming various temperatures for the arc, and he finally, after allowing for the length of time the maximum temperature is effective, assumes an average temperature of 3,200° C. A higher temperature should be arrived at in practice, for the maximum theoretical output coincides with about 5,200° C. The paper concludes with an estimate of the number of molecules in the arc that are split up into ions, and suggests comparisons with air ionised by means of radium. It may be that the proportion of gas ionised will be of determinative importance to the chemical equilibrium of gas compounds.

Electric Current Meter for Gauging of Rivers.—A recent issue of the *Electrical Engineer* reproduces from a report of the Department of Public Works of the New South Wales Legislative Assembly an interesting account of the gauging of rivers by means of electric current meters. Three years ago the Public Works Department procured two electrically recording current meters of type made by Amsler-Laffon, of Switzerland, and it has been found that these meters, even when used in dirty and muddy water, alter but slightly in rating, and give very satisfactory results. The meter can be used in streams of all sizes. It gives the mean velocity of the impulses. Only one section of the river need be taken. Gaugings can be taken with more rapidity and accuracy than with the rods, and the cost is less, as fewer men are required. Instead of using the meter attached to a metal rod so that it can be held rigid, it is suspended by the insulated copper wires, which allows the meter to turn in any direction, the screw being kept facing upstream by a four-blade tail. Leaden weights up to 60 lb., varying according to the velocity, are attached to keep the instrument at right angles to the flow; this allows of the meter being raised or lowered very quickly to any desired position on the vertical. To put the instrument into operation, fix the rudder, A, in the diagram by means of the screw, C; place the instrument on a metal bar, D, so that it is entirely free to turn in any direction with the current. Connect the terminals, 2 and 3, of the electric battery with L and U respectively on the meter. At every 50 revolutions of the axle on the wheel a small arm or wiper inside the meter revolves, completes the circuit, and causes the bell to ring. To inspect and oil the electric contact, the cover, E, must be removed. The bottom, E^1, should never be taken off. In order to empty the case, the outlet, F, should be opened, and water drained off each day. When using the "telephone, or buzza," connect two ends of the telephone wires to No. 4 and



ELECTRIC CURRENT METER FOR GAUGING OF RIVERS.

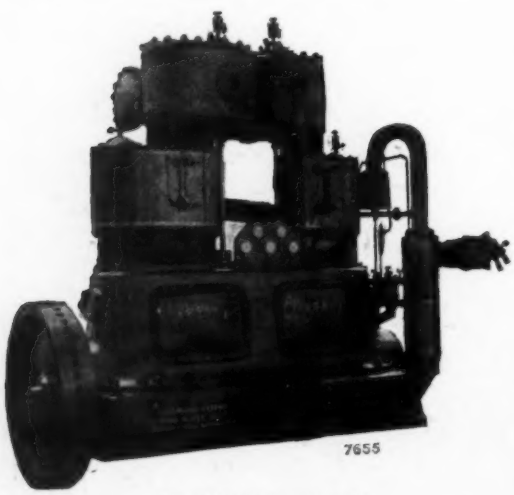
No. 5 clamps of the electric battery, and one wire from clamp No. 5 to U^1 on the meter; if the axis of the meter is going forward, one sharp tick is given; if reversed, two ticks. To measure the velocity of water, the mode of procedure is as follows: When the bell rings, observe on a stop watch the instant when the ringing ceases, and then observe the interval of time (expressed in seconds) till the next signal ceases. The beginning of the signal is only for advising the observer. The discharge is computed as in the case of the rod floats. Thus, let b in feet be the distance between each vertical, where d_1, d_2, &c., are the mean depth between each two verticals; V_1, V_2, &c., the measured mean velocity of the area between each two verticals; and A the area in square feet of the cross-section, then the total discharge is expressed in the formula

$$Q = b\,(V_1 d_1 + V_2 d_2 + etc.)$$

Then

$$V = \frac{Q}{A}.$$

The interval of time from signal to signal is denoted by the letter t; V denotes the speed of the water. If, for example, that interval has been 20 seconds, then $t=20$. Next, a tagged wire is stretched across the cross-section, and when a boat is available, two others above it for holding the boat in any required position: the insulated wires, with the meter and weights attached, pass over a pulley at the end of a pole projecting from the boat, so that the meter is well clear. The boat is then held in position by the two upper wires; the meter is suspended just under one of the tags on what might be called the cross-section wire. The insulated wire is marked at each foot, the measurement starting from the centre of the fan. Two methods of measuring velocity may be used with such a current meter as is described above: (*a*) multiple measurements, (*b*) unit measurements. Method (*a*) is the more exact, and, when the water surface is not fluctuating rapidly, is the method which should be adopted. The method by unit measurement is the best method to use when the water-level is fluctuating rapidly, and should be adopted when a river has been rising or falling 8 ft. or 9 ft. per day.



TWO-STAGE AIR COMPRESSOR.

New Two-stage Air Compressor.—The accompanying illustration is that of a high speed two-stage steam-driven air compressor as made by Messrs. Tilghman's Patent Sandblast Co., Ltd., Broadheath, the design of which embodies features of more than usual interest. Chief among these is the valve gear of the compressor which has no springs. The air cylinder valves are of the piston type, and are driven by eccentrics carried on the crank-shaft. Each piston valve is fitted with check valves of special design, which operate without the aid of springs, thus enabling the air to enter the cylinder without obstruction. The function of these valves is to prevent the compressed air from returning to the cylinder.

They are in equilibrium and close by the influence of gravity without shock at high speeds, to which end assistance is provided by the relative motion of the piston valve. Inspection of the check valves is easily effected by removing the piston valve.

Coming to the general features of the machine, which is of the vertical cross-compound type, the steam portion calls for no special mention, it being designed on ordinary lines. The cylinders are fitted with sight-feed lubricators placed on top and there is forced lubrication to all bearings and slides, the necessary oil pump being operated from the crank-shaft. Each air cylinder is double acting, with the valve chamber cast at the side, the cylinders, valve chambers, and cylinder ends being water jacketed. The inter-cooler, intended to keep an even pressure, has ample cooling surface, and in it water is circulated through ¾ in. copper tubes fitted with baffle plates, and water connection between the air cylinder and the cooler is by copper pipe. A patent air governor or automatic inlet valve is fitted, and acts with a variation of pressure of not more than 5 lb. If the working pressure is exceeded, the air inlet closes automatically, a partial vacuum being formed on both slides of the piston, which is thereby put into equilibrium, and the compressor runs without load. The crank-shaft steam governor keeps the speed constant, but if desired an air release governor can be fitted to this valve to slow the compressor when running light.

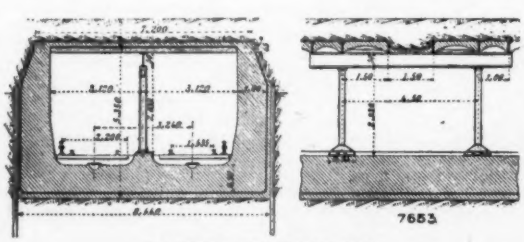
The following particulars of a test made with this machine will be of interest.

Test of high-speed two-stage steam-driven air compressor, with positively operated valves, forced lubrication, &c. :

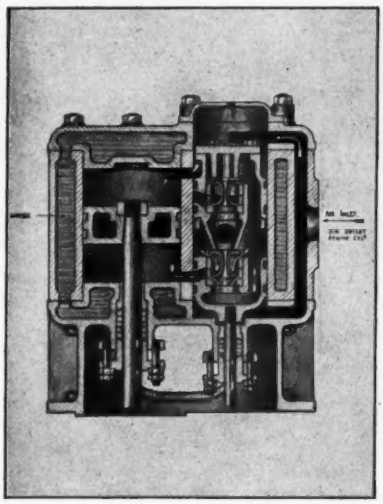
Air Cylinders, low-pressure, 16 in. dia., high-pressure, 9 in. dia.
Steam Cylinders, low-pressure, 19 in. dia., high-pressure, 12 in. dia.
Stroke of all, 9 in.
Speed, 250 revolutions per minute.
Volume swept by piston, low-pressure, in one minute, 550 cubic ft.
Air delivered, 500 cubic ft., showing a volumetric efficiency of 90·9 per cent.
Indicated h.-p. in steam cylinders, 102.
Isothermal compression of 500 cubic ft. free air would require 65·5 h.-p., so that the compressor gives a commercial efficiency of 65·7 per cent.
Steam consumption per hour, 2448 lbs.

Charlottenburg Extension of the Berlin Underground Railway.*—The extension of the Berlin underground electric railway to Charlottenburg and Westend, 2¾ miles in length, starts from the old Knie terminus and runs along the Krummestrasse, and Bismarckstrasse at a maximum depth of 40 inches below the roadway. The bed and sides of the tunnel are of concrete, and a triple lining of tarred millboard is provided in places where the bed is below the normal level of the ground water. The roof, of iron and concrete arches, is supported by central longitudinal girders upheld by pillars arranged between the tracks, as shown in the drawing. Ventilating shafts are provided about every 220 yds., ladders in these shafts affording a means of exit from the tunnel in the event of accident This section of the railway being too remote from the central station to be supplied direct with continuous current at the working tension of 750 volts, is served by an underground sub-station, at which the 10,000-volt. triphase current (periodicity 40) undergoes a double transformation down to working tension. At the Krummestrasse station the line branches off for Charlottenburg ; and here the line is doubled, the Westend trains running on the outer sides of the two island platforms, whilst those for Charlottenburg run between them, so that only passengers travelling from one branch to the other have to change platforms. The cost of the extension was 19½ million marks.

* *Le Génie Civil.*



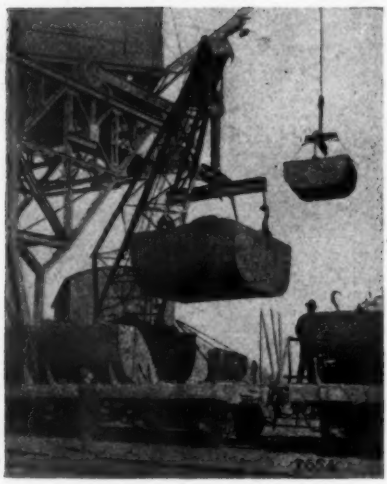
BERLIN UNDERGROUND RAILWAY.



TWO-STAGE AIR COMPRESSOR. VIEW SHOWING CHECK VALVES.

Coal and Ore Handling Plant at Walsun.*—An entirely new system of coal and ore handling plant has been laid down at the Walsun wharves of the Gutehoffnungshuette, on the Rhine. The length of quay along the river front is nearly 140 yds., with about 250 and 270 yds. of quay wall in the basin, which is some 460 yds. in length. The basin is 70 yds. across and occupies an area of 11 acres. The coal store is on the river side of the basin and the ore store on the landward side, their respective areas being nearly 4 and 3 acres. The wharves are served by about six miles of rails. The novel point about the system adopted is that, instead of tipping the whole wagons, the bodies are made detachable and these alone are tipped. Each wagon frame carries four 8-ton hinged boxes or skips with a tare of two tons each (see Fig.). These skips are loaded at the colliery, and on arriving at the wharf are lifted bodily by the crane, swung and lowered into the ship's hold, automatically discharged of their contents and returned to the wagon frame. This work is performed by 10-ton electric cranes, mounted on the wharves in front of transporter bridges and having a reach of 40 ft. Each crane can load 180—220 tons an hour, and at high water the capacity rises to 300 tons per hour. Similar cranes, travelling on the transporter bridges, deal with the

* *Glückauf.*



COAL AND ORE HANDLING AT WALSUN.

coal that has to be put into store. Each bridge has a span of 100 yds., and, like the cranes, is operated electrically. The bridges run on tracks 250 yds. in length. To ship the coal from the stockyard it is lifted by automatic six-ton grabs attached to the travelling cranes on the bridges; and similar grabs can also be attached to the cranes on the ground. The great advantages of this system comprise the increased capacity of the plant, the avoidance of damage to the coal in discharging the skips, and the possibility of working whether the water be high or low. At the same time a smaller wharf frontage and shorter length of rail track is sufficient than with other systems, and only two men are needed to operate each crane, instead of the six required for the ordinary tippler. The first cost of the installation is somewhat high, but additional cranes can be put in at about half the cost of tipplers. The current (polyphase, with a tension of 10,000 volts) is generated at the Sterkrade colliery and transformed at the wharf to 500 volts.

Generation and Utilisation of Power in Mines and Metallurgical Works.*—In the course of a paper on this subject, read before the jubilee meeting of the Association of German Engineers,* Dr. H. Hoffmann referred to the great importance attaching to the utilisation of coke-oven and blast-furnace gases, which, though costing nothing, are capable of furnishing nearly enough power to satisfy the requirements of the mining and metallurgical industries. The waste heat and gases produced in German coke works are sufficient to generate a continuous supply of half-a-million horse-power in good steam engines, or 10—20 per cent. more if utilised in gas engines. Similarly, the utilisation of the blast-furnace gas in gas engines would give a constant supply of a million horse-power. Except in connection with blowing engines, steam still occupies the premier position as a motive power, but great progress has been made—chiefly owing to the inventions of Leonard and Ilgner—in the application of electricity to winding engines, though only 10 per cent. of the coal raised in Germany is wound in this way. Sixty large sets of electrical winding plant, however, are being constructed by German makers—enough to raise 40,000 tons per shift. The introduction of the centrifugal high-lift pump has favoured the spread of electrical pumping, and there are about 100 sets of these pumps at work in the Ruhr district. In ironworks, electric hoists and conveyers are the rule, and attention is being directed to the application of electricity for reversing rolls.

There is a growing tendency to adopt electricity, even when no great monetary saving is anticipated, the inducement being the more efficient control afforded. Where primary gas dynamos can be installed, electric driving will nearly always be found the most advantageous system, the employment of direct-coupled gas engines being restricted to large units such as blast-furnace blowing engines. A considerable future is open to enterprise in the distribution of electrical power, so that collieries where a large quantity of coal is coked, and therefore a large store of power available, whilst the consumption on the premises is small, may be able to dispose of their surplus to works where the converse conditions obtain. This is now being done in Westphalia, a large electric company having contracted to buy current from producers and sell at a profit to consumers. In addition, three large collieries in the district are disposing of current to local communities and other consumers.

The Prevention of Accidents in Caisson Work.*—According to Razous, recommendations to the following effect have recently been issued by a French society that undertakes insurance against accidents in the building trades and public works:—No one should be allowed to work in caissons or compressed air generally un ess provided with a medical certificate of fitness, especially with regard to the heart and lungs, and these certificates should be renewed at least every six months. Workers incapacitated for more than a week should be considered as unfit, and not allowed to work in compressed air. Before starting work the caissons, &c., ought to be tested to double the working pressure, and this test

* *Stahl und Eisen.*

* *Le Génie Civil.*

should be repeated at the end of a year's working. All joints, angle brackets, hinges and door fastenings should be repeatedly examined, and the outer doors of air locks should be fitted with means for preventing the simultaneous opening of both doors of the same lock. The gearing of winches and motors should be fitted with shields, and the air pipes should terminate, in the caisson, in valves preventing the escape of air in the event of accident to the pipes or air supply, safety valves being also provided to relieve any surplus pressure above that needed to keep the water out of the caisson, and pressure gauges fitted to enable the actual pressure to be ascertained. Electric incandescent lamps should be used for lighting wherever possible, and all exposed wires should be well insulated. In all cases a number of lighted candles should be placed in the shaft of the caisson, to enable the men to escape if the main lighting system fails. The ladders must be kept in proper repair, and the several lengths securely attached together; and a hinged ladder should hang down into the working chamber from the shaft. All apparatus should be thoroughly overhauled once a week, and movable fittings and safety appliances should be sealed. Guard rails should be provided on all stagings wherever possible, and life-belts or life-lines where there is any risk of the men falling into the water. While work is proceeding, the foremen should constantly supervise the men and their tools. Sudden reductions of pressure, to facilitate the descent of the caisson, should be prohibited. Proper means should be provided for keeping the air fresh in the working chamber. In winter the locks should be warmed by coke fires in buckets outside, and cooled in hot weather by external layers of straw watered at frequent intervals. Small heated sheds, where the men can rest and change their clothes, should be provided close at hand in winter, wraps being supplied in the very cold weather. Coffee or weak tea should be given the men to drink. The men should be warned not to stand under the shaft while working, and when concrete is being laid the shaft should be inspected for the presence of hanging stones before the men begin to ascend. Only one door of an air lock should be open at a time, and nothing whatever should be placed on the doors in winter, and when the depth is more than 30 ft. below the surface of the water the men should come out slowly, taking three minutes when the depth is 15 ft., and increasing the time with the depth, so that at 60 ft. twenty-five minutes are allowed. The length of the shift should be varied inversely with the depth of sinking, being eight hours, with a rest of equal length before resuming, for a depth of 45 ft. in loose ground, and 30 ft. in hard soil or rock, whilst six-hours' shifts, with intervals of ten hours, should be worked when the depth reaches 45—70 ft. in loose ground, or 30—50 ft. in hard ground. These recommendations have also been endorsed by competent authorities in Germany.

The Relative Corrosion of Wrought-Iron and Steel.*—On one hand we have the very general public opinion that steel corrodes not only faster, but very much faster, than wrought-iron, an opinion held so widely and so strongly that it cannot be ignored. On the other hand we have the results of direct experiments by a great many observers, in different countries and under widely differing conditions, and these results certainly tend to show that this popular belief is completely wrong, and that on the whole there is no very great difference between the corrosion of steel and wrought-iron. Under certain sets of conditions steel seems to rust a little faster than wrought-iron, and under others wrought-iron seems to rust a little faster than steel. Thus taking the tests in unconfined sea water as a whole, wrought-iron does constantly a little better than steel; and its advantage seems to be still greater in the case of boiling sea water. In the few tests in alkaline water wrought-iron seems to have the advantage over steel, whereas in acidulated water steel seems to rust more slowly than wrought-iron.

When I review our conditions in the light of this apparent contradiction between popular belief and the result of the differences between steel and wrought-iron which ought to cause a difference in their rapidity of rusting, there are three prominent differences: (1) Blowholes; (2) Manganese; and (3) the presence of cementite in the steel and of cinder in the wrought-iron. Let us take these up in order and see how they require that direct tests should be very prolonged or pushed to destruction.

(1) Blowholes exist in steel, but not in wrought-iron. But blowholes, at least blowholes which do not weld up and thus cease to exist, are not necessary. Yet they are to be prevented only by care and skill. Hence, get your steel only from careful and trustworthy makers.

(2) Steel always and almost necessarily contains more manganese than wrought-iron. This may or may not hasten its rusting. If it does, then its effects ought to be made manifest even in short-time tests. From the fact that such tests do not show that steel rusts materially faster than wrought-iron, I infer that this manganese is probably not a serious cause of rusting.

(3) Steel is generally richer than wrought-iron in cementite, the iron carbide Fe_3C. Wrought-iron always contains very much more cinder than steel. Each of these substances, the cementite of the steel and the cinder of the wrought-iron, may have a double influence on corrosion, hastening it through difference of potential and retarding it by acting as a mechanical barrier like so much paint, to exclude the oxygen, or the air, or the water. It is not clear that the influence of difference of potential ought to change materially as corrosion proceeds; but it is clear that that

* Abstract of a paper by H. M. Howe, read before the American Society for Testing Materials.

mechanical protection given by the plates of cementite and of cinder ought to increase as corrosion proceeds. When a piece of wrought-iron, for instance, is first exposed to corrosion, only the outcrops, so to speak, of the sheets of cinder come to the surface; its mechanical protection is very small. But as corrosion proceeds, and more and more of the metal which at first overlay the sheets of cinder is eaten away, the remaining cinder forms a larger and larger proportion of the outer surface, and therefore protects a constantly increasing proportion of the underlying metal from corrosion. In short the mechanical protection afforded by the cinder ought to increase as corrosion proceeds. Here, then, is a cause, which as corrosion proceeds, should continuously tend to retard the corrosion of wrought-iron, and to make it compare more and more favourably with steel. But, in like manner, as steel is gradually corroded away, more and more of its surface should come to be composed of cementite, and this fact should tend to retard the corrosion of steel, because cementite, too, should protect the underlying free iron or ferrite.

These causes may, in time, reverse the initial relative rapidity of rusting of steel and wrought-iron. Steel which in the first few months may rust faster than wrought-iron may, on greatly prolonging the experiments, or pushing them to destruction, actually rust more slowly, and *vice versa*.

Now of the two, the cinder of wrought-iron ought to gain more than the cementite of the steel in its value as a mechanical retarder of corrosion, as time goes on and more and more of the metal is eaten away. The reason for this is that the cementite is in such extremely minute microscopic plate that the eating away of a very small quantity of the iron from above them ought to bring very nearly the full proportion of this cementite to the surface; whereas the much larger and more distantly scattered plates of cinder in wrought-iron would not constitute their full share of the surface until a much thicker layer of initially overlying metal had been eaten away. This, then, may be the true explanation: that is, the reason why steel does not rust faster than wrought-iron in our direct tests, though it does in actual use, is that our direct tests are too short to bring out the full protective action of the cinder of the wrought-iron. Or the reverse may be true. As time goes on, the harmful effect of the difference of potential of the cinder may grow more than its protective action. Let us, therefore, henceforth push our tests to destruction.

Two other points: Sheet steel roofing may rust faster than iron because it holds the paint better, and yet steel in other forms, like tubing, may rust no faster than wrought-iron. Again let me emphasize the difference between different steels. Carelessly made steel, containing blowholes, may rust faster than wrought iron, yet carefully made steel, free from blowholes, may rust more slowly. Recognise that any difference between the two may be due not to the inherent and intrinsic nature of the material, but to defects to which it is subject if carelessly made. Care in manufacture and special steps to lessen the tendency to rust, might well make steel less corrodible than wrought-iron, even if steel carelessly made should really prove more corrodible than wrought-iron.

The "Backstrom-Smith" Steam Turbine.—A new type of steam turbine has recently been installed at the power station of the Milwaukee Electric Railway Co., where it is employed for driving a 400-k.w. alternator. Full details of the set appeared in a recent issue of the *Street Railway Journal*. The turbine is of the multicellular inward flow type, and works under constant stage pressures with varying quantities of steam to suit varying loads. It is provided with means for meeting the requirements of changing loads without throttling, making it nearly as economical for light loads as for the heaviest. This object is accomplished by using flexible steel bands, which are secured to the periphery of the nozzle sections and to spools or rollers mounted on a collar or ring, which has a limited rotary travel around the housing in which each turbine wheel revolves. A movement of this collar winds or unwinds the steel tape on each of the spools, uncovering or covering the series of nozzles or ports, which admit steam to the active buckets of the turbine wheels. This winding or unwinding of the steel tape is automatic, the device being so arranged that the flow of steam is always in proportion to the load, steam entering the different stages at a pre-determined and constant pressure but in varying quantities, which depend upon the number of nozzles covered or uncovered by the steel tapes. This automatic regulation is accomplished by means of a shaft running the full length of the turbine in the bottom of the housings. At proper intervals on this shaft are keyed pinions which engage corresponding teeth, cut in the ring or collar on which the several tape rollers are mounted, these rollers engaging with short racks secured to the nozzle ring or housing. The minutest motion of the shaft results in winding or unwinding the tape on the rollers, thus closing or opening more or less of the nozzles. The motions of the shaft operating this ingenious cut-off mechanism are controlled by a governor which controls a flow of oil under constant pressure, and by means of a pressure cylinder and a rack and pinion, rotates the shaft in one or the other direction. The governor is dependent upon the proper action of the lubricating mechanism, as any accident to the latter results in an automatic stopping of the turbine which insures the machine against self-destruction. In addition to this governor, with its two important functions, a safety device is provided in the shape of a safety governor controlling a butterfly valve, which closes automatically when the

* From the *Electrician*.

turbine speed reaches 5 per cent. above the normal, but is otherwise inoperative.

The 400 k.w. size has ten wheels or runners, the bucket face of each successive wheel being wider. All the runners have an equal number of buckets of a uniform cross-section. This feature applies also to the nozzles.

It is held that superheated steam is not as essential to the economical operation of this turbine as in others. In the first place, it is claimed that there is a minimum of condensation, because of the constant pressure and temperature maintained at all loads in all the stages of the turbine. The next contention is that all the water contained in the steam is separated from it and that this drained into the succeeding stage by automatic means, is at once in part, if not wholly, re-evaporated, thus becoming useful energy. Again, by using high steam velocities, the surplus velocity appears in the form of superheat—which greatly reduces internal condensation and skin friction.

The turbine is arranged so that it may be quickly converted into an economical non-condensing type, should the condensing apparatus get out of order or become inoperative. This is done by providing an auxiliary exhaust at a point favourable for exhaust to atmosphere. This early exhaust relieves the turbine from a certain amount of back pressure which would arise from forcing a large volume of already fully expanded steam through a number of useless and idle turbine wheels, causing a considerably reduced efficiency and other unfavourable effects.

The "Melms-Pfenniger-Sankey" Steam Turbine.—Some remarkable results have recently been obtained during the tests carried out by Prof. Schröter with a steam turbine of the above-named type, details of which were given in *Engineering*.* The turbine is based upon a combination of the impulse or action principle for the high-pressure end, and of the reaction principle for the low-pressure end of the turbine. At the high-pressure end the fixed guide-blades are arranged for the admission of steam over only a small portion of the circumference—that is, this portion of the turbine works on the partial admission system. In consequence of this, the diameter of the drum can be made large at the high-pressure end, and, following this, there is a step-down caused by the smaller diameter of the first part of the reaction portion. The annular surface thus formed enables the axial thrust of the steam due to the reaction portion to be balanced in a remarkably simple manner. The adoption of the impulse principle for the high-pressure end of the turbine makes possible a great reduction in the length of the drum, and enables it to be of a form which is cheaper to manufacture than that usually adopted in the ordinary reaction turbine. Further, the diameter being everywhere large, "whipping" of the drum cannot occur. This casing being also shortened, there is practical immunity from the serious troubles caused by differences of temperatures, which in the ordinary form gave rise to "hogging" of this casing, and there is also a marked reduction in the number of rows of blades necessary, as compared with the ordinary time, in which the reaction principle is used throughout.

The turbine, which was rated at 1,000 b.h.-p., was coupled to two continuous-current generators of 250 kilowatts each, which did not represent anything like full load conditions; in fact, the turbine could have driven dynamos of over 600 kilowatts output.

Load in round numbers k.w.	500	400	280	150
Average number of revolutions per minute	2,548	2,469	2,477	2,489
Absolute steam pressure, lbs. per sq. in.	191	189	192	182
Actual temperature of steam deg. C.	317·5	312·4	308·2	306·2
Actual temperature of steam deg. F.	603	594	587	583
Vacuum (absolute pressure in lbs. per sq. in.)	0·48	0·43	0·34	0·36
Output measured at the switchboard .. .. k.w.	504·2	402·9	277·5	146·6
Consumption of steam per kilowatt hour.. .. lb.	17·2	17·5	18·5	22·5

Live Steam Heated Feed Water—Its Effect on the Output and Efficiency of Steam Boilers.*—In comparing modern electric generating works with similar works equipped ten or fifteen years ago, one of the most striking features in the former is the increase in output of the generating units in the engine-room and their relative decrease in size. It is now common practice to instal three or four times the amount of power in a given size of engine-room which was then possible. No such evolution and improvement has taken place in the boiler-house, probably in every case the same boilers are at work, doing practically the same duty and at approximately the same efficiency as they gave when first put to work. To supply sufficient steam for the larger generating units now installed in the engine room more boilers have had to be installed; thus the boiler-house equipment becomes longer than the engine-room, and complicated and wasteful arrangements of steam pipes ensue, which are expensive and undesirable.

In the modern power houses, where large generating units are installed, one of two things usually happens; either the "complete unit system" is sacrificed, and the boiler-house equipment occupies a greater length of space than the engine-room equipment, long steam-pipe ranges and complicated steam connections being thereby rendered necessary; or the "complete unit system" is adhered to, but, owing to the extra space required by the boiler plant, the generating units in the engine-room are placed at such wide centres as to cause

* July 6th, 1906.

* Abstract of Paper read before the I.M.E.A. by G. Wilkinson.

waste of floor space. The remedy is to increase the size and steaming capacity of the boilers, so as to make the supply of steam per foot run in a single row of boilers equal to the demand per foot run of engine-room generators.

To do this it is necessary to greatly increase the rate of transmission of heat from the hot furnace gases to the water within the boiler, then the size of furnace and rate of combustion can be increased without materially increasing the temperature of the waste gases passing to the chimney, and when called upon to meet sudden heavy loads the duty of the boiler can be further substantially and efficiently increased by using supplementary oil, steam, and air jets on the top at the back of the ordinary coal fire. Such a fierce and concentrated combustion taking place in a boiler furnace working under ordinary conditions would not only wastefully heat the gases passing to the chimney, but might also overheat and burn the boiler plates or tubes, with the risk of collapse.

The author is of opinion that maximum evaporations of from 10 lbs. to 20 lbs. per square foot of heating surface per hour can be obtained in regular practice with suitably designed boilers and accessories, and given the opportunity, a boiler-house equipment can be designed and put down which, with a single row of boilers, would supply steam to any British power house existing to-day with a maximum evaporation of 15 lbs. of steam per square foot of heating surface and with a total heat loss not exceeding 20 per cent.

From considerations advanced in the paper it will be clear that if steam boilers are to give continuous high duty, the whole of the water within them must be maintained at high temperatures, and the nearer the maximum temperature approaches that of the steam the greater will be the output of any boiler.

In order to approach this ideal condition of affairs it is necessary to employ some special method of heating the boiler feed water to steam temperature. One practical method of doing this is found in the well-known "Druitt Halpin" thermal storage.

Another and more recent method of increasing the temperature of the feed water to approximately that of the steam is by means of feed-water heating.

If for no other reason, a live steam feed-heater justifies its existence, because the increase in temperature in the water crystallises the lime, keeping it out of the boiler. Such a feed-heater should be provided with means for removing the air and other gases held in solution by the feed-water. The boiler would thus be preserved and variation of temperature inside the boiler prevented.

In the case of the boiler of plain Lancashire type at the Harrogate Electricity Works, a set of comparative trials were made for ascertaining the extra efficiency of very high temperature feed as against the high temperature feed of a three-set economiser of Green's type containing 288 pipes. The temperature of the very high temperature feed was only 10° F. below the steam temperature, and was made by the Dales and Braithwaite live steam feed-water heater. The temperature of the economiser feed supplied to the heater was 265° F.; already very high; and 218° F. above the cold water, which was 47° F. The steam temperature was 358° F., so that the heater had to supply 93° F., to steam temperature, and actually did contribute 83° F.

The general conditions were produced as exactly as possible for the comparative test with the economiser only, and the net result was over 7 per cent. in favour of the live steam feed-heater. With so little margin for improvement as existed in the efficiency of the boiler and economiser, the above result is remarkable; and this live steam-heated feed reached the maximum efficiency attainable under the conditions, the terminal temperature at the chimney bottom being lowered by infiltration of air to the flues, and the chimney draught was low, being an average of about 0·475 in. of water.

With greater differences between the economiser feed and the steam temperature, correspondingly greater improvement would naturally follow the use of full temperature feed.

The particulars of these trials, which were made at normal rates of combustion for Lancashire boilers, namely, 22·147 lbs. and 24·27 lbs. of coal burnt on the square foot of grate area per hour, are as stated below.

1. Economiser and live steam heated feed:—	
Calorific value of coal, 14,200 B.T.U. per pound.	
Rate of combustion per ft. sup. grate per hour, 22·147 lbs.	
Steam pressure, 150 lbs. absolute temperature, 358° F.	
Economiser feed to heater, 265° F.	
Heater feed to boiler, 348° F.	
Efficiency of boiler and economiser from water at 47° F. ..	Per cent. 76·4
Efficiency of superheater ...	3·0
Radiation, taken at	7·0
22 lbs. of air at 50° per lb. of coal = 23 lbs. of products at 400° F. + 50° F. (atmosphere) = 350° F. above atmosphere...	13·6
Total heat of fuel ...	100·0
2. Economiser heated feed only:—	
Calorific value of fuel, 14,200 B. T. U. per pound.	
Rate of combustion per ft. sup. grate per hour, 24 27 lbs.	
Steam pressure, 150 lbs. absolute temperature. 358° F.	
Economiser feed, 234° F.	

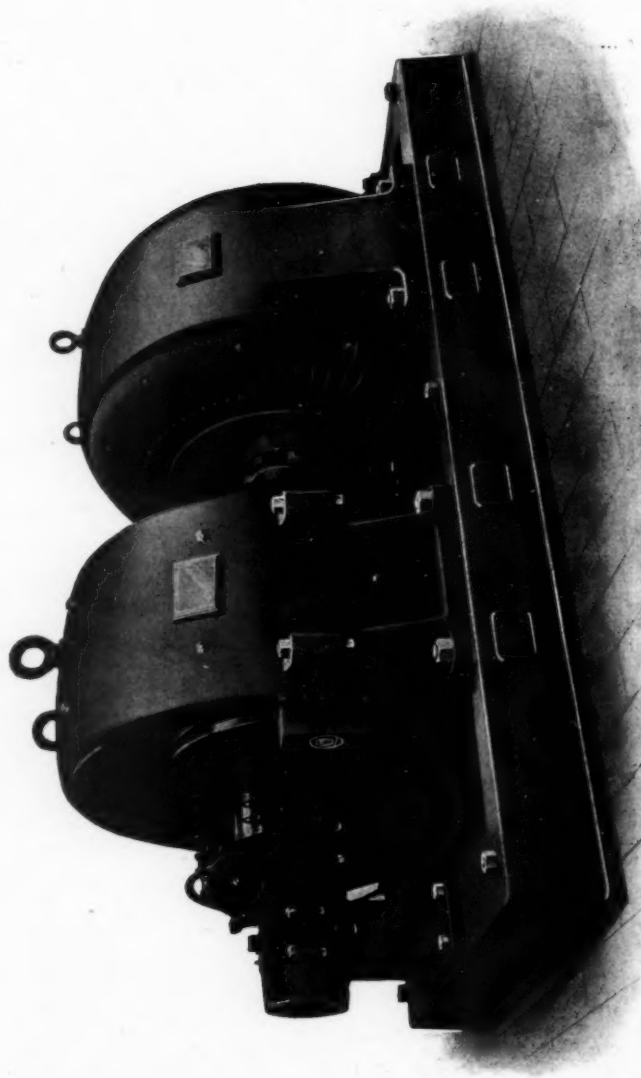
	Per cent.
Efficiency of boiler and economiser from water at 56° F...	69·844
Efficiency of superheater ...	3·27
Radiation taken at	7·0
22 lbs. of air to 1 lb. coal; 23 lbs. products at 571° F. terminal temperature	19·886
Total heat of fuel ...	100·000

In the terminal temperatures given no allowance for infiltration is made.

Other tables from tests showed that, taking medium duty and cold feed-water with economiser only and with economiser and feed-heater, the coal burnt per hour was respectively 1,004 lbs. and 929 lbs.; the water evaporated per hour was 7,201 lbs. and 7,956 lbs.; the water evaporated per hour per square foot of heating surface was 6·54 lbs. and 7·23 lbs.; the water evaporated per pound of coal was 7·17 lbs. and 8·56 lbs.; and the combined efficiency of plant was 61·1 and 73·87 per cent.

Electric Power for London.

By the rejection of the London County Council Electric Supply Bill, the Parliamentary Committee appointed to inquire into the merits of the scheme has provided a bare chance that London may yet be saved from the establishment of a gigantic municipal enterprise involving most serious risk to the ratepayers. It is to be feared, however, that as the problem of electric power supply has now become a question of party politics, we shall find the next session of Parliament occupied in the consideration of another and still more ambitious proposal brought forward by the county council, and that the Government will once more favour the municipal Bill, and practically refuse a hearing to the promoters of independent schemes. The greatest defect of the rejected Bill was that it imposed no obligation to carry into effect any of the powers sought, and we are glad to observe that the committee laid down the principle that the council ought to be compelled to exercise any powers granted. There is no objection to the further opinion that the best means of providing for the supply of electrical energy in bulk is to create a central authority with ample powers and clearly defined duties. But we object most strongly to the recommendation that the London County Council should be that authority. In the first place, the area of the administrative county is not sufficiently extensive for the formulation and working of a really satisfactory scheme by which London and the surrounding districts could be supplied; and in the second place, the same area has already been proved to be far too large for the administrative capacity of the body under whose control it has been placed by the ratepayers. Every industrial business hitherto undertaken by the London County Council has been characterised by mismanagement, extravagance, and financial loss, and there is no reason for believing that the new business upon which the council is so anxious to embark will be any more fortunate than its predecessors. If there is to be a central electrical authority it ought to be composed of members who are competent to legislate honestly for the good of the community, and not of men who may be able to manage their personal affairs in a businesslike manner, but in public affairs appear to be guided solely by party politics and socialistic fervour.



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ELECTRIFICATION OF THE GREAT WESTERN RAILWAY SUBURBAN LINES: "PEEBLES-LA COUR" CASCADE CONVERTER USED IN THE SUB-STATION EQUIPMENT.

(See page 139.)

Metallurgical Progress.

By PERCY LONGMUIR.

FOUNDRY PRACTICE.

The Beneficial Effects of adding high-grade Ferro-Silicon to Cast Iron.—Mr. A. E. Outerbridge, in a paper read before the American Foundrymen's Association, describes his experience in changing the grade of cupola metals by means of additions of ferro-silicon. Experiments made in 1886 were not successful, owing to the fact that the richest grades of ferro-silicon then available only ran from 10 to 18 per cent. silicon, and the solid additions could not be made without appreciably affecting the temperature and fluidity of the molten metal. Preheating the alloy did not result in much improvement, and the work was discontinued. At the same time it was found that the addition of ferro-manganese, 80 per cent. alloy, accomplished the object sought in car-wheel mixtures without the necessity of heating the alloy. On the introduction of high grade ferro-silicon and of nearly pure silicon, the work was again taken up, and some interesting results have been obtained. Tests made by adding silicon of 98 per cent. purity resulted in failure, owing partly to the high melting point of silicon, and partly to its levity, which caused the powder to float to the surface if sprinkled into the ladle, or to simply cake if placed at the bottom. With a 50 per cent. ferro-silicon very different results were obtained, and the alloy added in the form of a coarse powder to the ladle, resulted in a perfect incorporation.

The softening effect of silicon is well known, and as one would expect, Mr. Outerbridge's treated metal showed considerably less chill than the untreated metal. It is also well known that soft irons are weak, hence much interest is attached to Mr. Outerbridge's results, in which not only were the treated bars softer, but they were also stronger than the untreated ones. In other words, increased softness and increased strength, usually antagonistic properties, were combined. Castings poured from the treated metal were in the form of small pulleys having rims about ¼ inch thick, and these castings are usually turned at a speed of 25 ft. per minute. The treated pulleys were turned without destroying the cutting edge of the tool, at forty revolutions per minute.

Analytical tests showed the actual increase in

Results of Tests of Ferro-Silicon in Ladles.

Date.	Remarks. Per cent. Si.	Breaking Strain (Pounds).	Deflection (Inches).	Resilience.	Shrinkage (Inches).	Per cent. Gain.		
						Breaking Strain.	Deflection.	Resilience.
						Per cent.	Per cent.	Per cent.
Oct. 10, '05	¼ lb. Hand	2265	·120	45·30	·192			
	Ladle	2155	·112	40·09	·191			
	Gain	110	·008	5·21		5·1	7·14	13
Oct. 11, '05	¼ lb. Hand	2215	·137	50·51	·182			
	Ladle	2165	·124	44·60	·185			
	Gain	50	·013	5·91		2·3	10·4	13·2
Oct. 14, '05	¼ lb. Hand	2600	·152	65·79	·196			
	Ladle	2055	·116	39·18	·188			
	Gain	545	·036	26·61		26·5	31	67
Oct. 15, '05	¼ lb. Hand	2330	·143	55·45	·183			
	Ladle	1893	·110	34·60	·183			
	Gain	437	·033	20·85		23·8	30	60·2
Oct. 16, '05	¼ lb. Hand	2210	·124	45·54	·183			
	Ladle	2120	·112	39·44	·185			
	Gain	90	·012	6·10		4·2	10 7	15·4
Nov. 13, '05	1 lb. 200 lb.	2370	·139	54·76	·186			
	Ladle	2050	·118	40·19	·184			
	Gain	320	·021	14·57		15 6	17·8	36·2
Nov. 21, '05	1 lb. 200 lb.	2178	·128	46·24	·188			
	Ladle	2000	·119	39·60	·182			
	Gain	178	009	6·74		8·9	7·5	17

silicon to be slightly less than the calculated increase, and further tests showed that there is a limit to the amount of alloy that can be incorporated depending on the initial heat of the metal and the size of the ladle. A further fact noted is that a given increase of silicon, say 0·25 per cent., is more effective as a softener than an equal increase of silicon imparted through the cupola charge. Further, an increase of silicon in the cupola charge always results in a corresponding decrease in the strength of the metal. The rationale of the increase in strength with increased softness noted in these experiments is in all probability to be found in the deoxidisation of the iron by the silicon added in its nascent condition. It is now generally thought that cupola metal contains a small amount of dissolved oxide of iron, and that this oxide is a weakening element. Silicon has a strong affinity for oxygen, and presumably seizes upon the oxygen of the dissolved oxide, liberating iron and forming silica which, owing to its low specific gravity, floats to the surface. Finally, the results of a few tests, showing the effect of additions of powdered ferro-silicon to the ladles, are as shown in the table on the preceding page.

Open Hearth Steel Castings.—Mr. W. M. Carr's sixth article in the June issue of *The Foundry* is a continuation of basic practice, and in it the details of a typical heat are followed. The appended elimination curve practically summarises this aspect. In giving details of recarburising, which must be done in the ladle, it is shown that ordinary grades of ferro-silicon must be melted in an auxiliary furnace before adding to the ladle. High grade ferro-silicon may be added in the solid form without chilling, a remark also applicable to ferro-manganese. Methods of calculating these additions in regard to the desired contents of carbon, silicon and manganese are given in full. Turning to the losses of the process, it is shown that these may vary from 6 to 12 per cent. of the metal charged. In representative plants with established and extensive experience, a yield of 93 per cent. in the ladle can be considered a fair average.

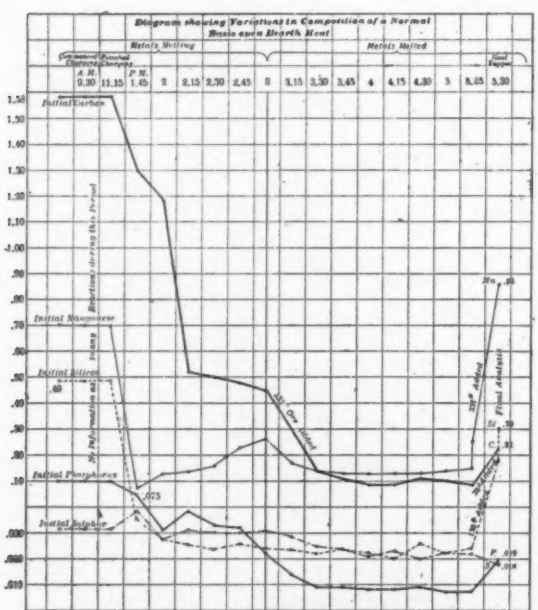


Diagram showing Variations in Composition of a Normal Basic open Hearth Heat
Metals Melting
Metals Melted
Initial Carbon
Initial Manganese
Initial Silicon
Initial Phosphorus
Initial Sulphur
Mn. Oxidised during this Period
Mn. Reduction during this Period
Mn. Oxidised during this Period
Mn. Oxidised during this Period
Mn. Oxidised

of zinc should be used. Metallic lead and tin are obtained in very pure forms. Good brands of lead contain 99·95 per cent., whilst tin may be obtained up to 99·8 per cent. purity. When unknown brass scrap has to be used, the plan advised is that of sorting into grades and melting down into ingots. These ingots are analysed, and may be then used in alloying with advantage and certainty. Following this, the author examines some of the more general aspects of alloys, and in conclusion gives a few words on copper castings. The only way to obtain good electrical castings is to melt pure electrolytic copper in a plumbago crucible under a layer of charcoal. When thoroughly melted, add 2 per cent. silicon copper, stir with a stick, and cast as soon as ready. Practical experience alone will show the correct temperature for casting copper in sand; it is, however, noted that it should not be cast boiling, but a fairly high temperature is necessary.

Bronze and Red Metal Alloys.—Mr. C. D. Robb, writing in *The Metal Industry*, gives a series of mixtures suitable for specific purposes. The following three are stated to be specially adaptable for the production of bronze candelabras, art objects, &c.

	1.	2.	3.
	Per cent.	Per cent.	Per cent.
Copper	90·0	90·0	90·0
Tin	6·0	8·0	8·0
Zinc	3·0	0·9	—
50 per cent. magnesium copper	0·3	0·3	0·3
Lead	0·7	0·8	1·7

The use of magnesium as a deoxidising agent is strongly advocated, and it is stated to be of special value when melting up filings, turnings, or old metal.

The Problem of Oxidation in Brass Foundry Practice*—At the outset, the author states that from a foundry point of view comparatively few studies have been made as to the direct influence of oxygen. Taking copper first, it is shown that oxygen free copper solidifies at a temperature of 1,084° C. but increments of oxygen steadily lower this temperature until at 3·5 per cent. cuprous oxide the mass solidifies at 1,065° C. Further increments of oxygen raise the solidification point, and it is noted that up to 3·5 per cent. cuprous oxide the oxide is soluble in the copper, but when this content is exceeded the oxide appears structurally free. In a similar manner, but to an extent as yet unknown, silver, nickel and iron exhibit similar phenomena, and though difficult this effect of oxygen demands most careful investigation. At the present moment the chief drawback lies in the difficulty of accurately estimating oxygen, and the chemist who removes this difficulty will give a powerful incentive to research in a field of direct value to the brass founder. Of the metals used in brass founding, copper, nickel and zinc are the most readily oxidised, and in the case of copper and nickel the oxides formed remain in the metal and affect the properties to the extent present. To a somewhat less degree tin will also unite with oxygen and form an oxide which is retained by the metal. Furthermore, metallic tin will under certain conditions reduce copper oxide, but the oxide of tin which results is retained by the alloy. In indicating the practical remedies adopted, it is shown that a charcoal covering alone is useless and must be supplemented by a deoxidising agent. The latter comprise zinc, phosphorus, silicon, manganese, aluminium and certain of the rarer metals. Zinc and phosphorus are the most familiar, the former being used in the metallic form and the latter as phosphor copper or phosphor tin. Manganese and silicon are used in either the cupro or the ferro form. Cupro alloys should be alone used for copper castings, but the ferros, provided they are high in either manganese or silicon, may be used for alloys, in which the introduction of iron is often an advantage. Nickel castings are deoxidised by means of high ferro-manganese, but when the iron introduced is a disadvantage then metallic manganese by the Goldschmidt process is substituted for the ferro alloy. In the case of zinc, oxidation is less of an evil than with copper or nickel, as the oxide is not retained, but where exact contents of zinc are required then the amount lost in melting must be allowed for in making up the charge.

* P. Longmuir, *The Metal Industry*.

The Tumbling Barrel and its Uses.—Mr. H. J. Hawkins indicates, in *The Foundry*, a novel use for tumbling barrels. The usual water tumbling barrel is used as follows: After cleaning out sand and water, from one half to one pound of soap powder is added to sufficient clean water to make a thick, creamy lather and introduced into the barrel. The castings are tumbled from two to three hours and, as the author states, with surprising results. The operation is stated to be specially useful for malleable castings, and it is possible to finish work in this manner and leave it in fit state for brass or copper plating.

STEEL, ITS TREATMENT AND PROPERTIES.

Nickel and Carbon Steels.—Mr. E. Dixon records in *Engineering* some interesting results obtained from experiments on nickel steels by Messrs. Thomas Firth & Sons, Ltd. At the outset the chief advantage of nickel steel as compared with carbon steels are stated to lie in (1) higher limit of elasticity, (2) higher ultimate tensile strength, and (3) higher resistance to shock or fatigue. These features are illustrated by a series of tensile tests obtained from steels of varying nickel content. Taking an ordinary carbon steel (0·35 per cent.) as used for crank shafts and connecting rods of

petrol engines, the treatment applied is usually that of oil hardening at 1,450° or 1,600° F., followed by annealing at a temperature of 900° F. This treatment would give results of the following order:—

Treatment.	Elastic Limit. Tons per sq. inch.	Ultimate Tensile Strength. Tons per sq. inch.	Elongation per cent. on 2 ins.
Heated to 1,450° F., annealed at 900° F.	21 to 25	40 to 45	24 to 28
,, 1,600° F., ,, 900° F.	28 to 32	45 to 50	18 to 22

The following results show the influence of nickel on a similar type of steel:—

	Treatment.	Elastic Limit. Tons per sq. inch.	Ultimate Tensile Strength. Tons per sq. inch.	Elongation per cent. on 2 ins.
1	Heated to 1,450° F., annealed at 900° F.	25 to 28	40 to 45	28 to 30
	,, 1,600° F., ,, 900° F.	28 to 30	44 to 48	26 to 28
2	,, 1,450° F., ,, 900° F.	52 to 55	58 to 60	20 to 22
	,, 1,600° F., ,, 900° F.	No change takes place.		
3	,, 1,450° F., ,, 900° F.	56 to 60	72 to 75	16 to 18
	,, 1,600° F., ,, 900° F.	No change takes place.		

	Carbon per cent.	Nickel per cent.
No. 1 contained	0·21	2·30
No. 2 ,, ...	0·26	2·60
No. 3 ,, ...	0·32	2·82

These results clearly show the behaviour of the two steels in the oil tempered state. Tests designed to ascertain the resistance offered to shock or fatigue also show a marked superiority in the case of nickel steels. Further experiments have shown that a yet higher ratio of elastic limit to maximum stress, without a material decrease of elongation, may be obtained by the addition of chromium to nickel steel. However, owing to the toughness of such steels considerable difficulty and additional cost may be experienced in machining intricate engine parts, therefore for commercial reasons it has been found necessary to limit the chromium additions. The following tests were obtained from a steel containing:—

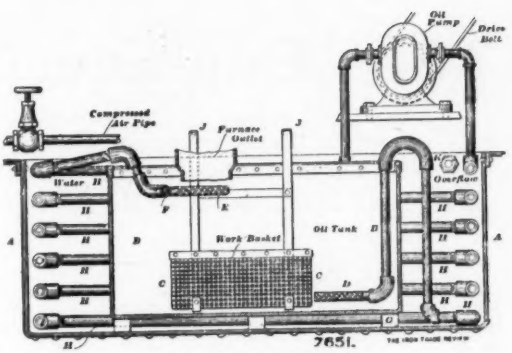
Nickel	5·0 per cent.
Chromium	0·60 ,,
Carbon	0·22 ,,

Normalised at ° F.	Elastic Limit. Tons per sq. inch.	Ultimate Tensile Strength. Tons per sq. inch.	Elongation per cent. on 2 inches.
1,400	75·11	103·94	9
1 300	50·59	62·63	18
1 200	59·85	64·98	16
1,100	53·06	68·00	15
1,000	46·30	63·36	17
900	60·70	66·44	14
800	64·65	71·70	13
700	70·45	74·73	11

These results show the steel to reach its softest point under normalised conditions when heated to 1,000° F., but it again softens between this temperature and 1,300° F., after which a change occurs, and at 1,400° F. the steel becomes self hard, and thereby exceedingly difficult to machine. The same steel, furnace-annealed at 1,175° F. and allowed to remain in the furnace till cold, gave an elastic limit of 45 tons per sq. in., a maximum stress of 54 tons, and an elongation of 27 per cent. on 2 inches. These results, in conjunction with others obtained by shock testing, show the steel when annealed at 1,175° F. to be in perfect condition for high speed engine construction.

The Hardening and Tempering of Interchangeable Tool Steel Parts of Delicate Structure.—The chief feature of an article under this heading, by Mr. J. V. Woodworth, in the *Iron Trade Review*, lies in a special combination of hardening furnace and quenching tank. Briefly the principle adopted is that of a travelling chain on which the steel articles are hung, and travelled down through an eight-burner muffle furnace, and from thence into an oil bath. The capacity is represented by about 5,000 wedge slides per day, and the work was performed at a labour cost of 2 cents per 100, as against a previous cost of 50 cents per 100 articles. The tank placed beneath the muffle is shown in the appended figure, and it will be noted that *A* is an outer or water tank; *B* the oil tank; *H* a coil through which heated oil is pumped and cooled; *K* an overflow for water; *F* and *E* coil inlets for hot oil, and *D* the discharge pipe for cooled oil. An automatic device for tempering is described as follows:—The machine consisted of a bed on four legs, equipped with an horizontal burner

about 10 in. long and made from 1¼ in. pipe. An endless chain, fitted with sheet pockets and carried by two sprockets passes this burner. The articles for tempering are placed in the pockets, and in passing the burner are tempered to a blue, and on arriving at the opposite end of the table fall out into a box on the floor. This method of oil quenching and subsequent tempering is stated to have given very satisfactory results, and to have resulted in a considerable reduction in working costs.



THE HARDENING OF STEEL.

GENERAL METALLURGY.

Remarks on the Solidification of Copper.—M. P. Dejean prefaces his remarks by quoting some of the more recent determinations, which show a variation of from 1,084° down to 1,035° C. In the author's experiments temperatures were determined by means of the thermo-electric couple, and the solidification curves photographically recorded. In calibrating the thermo couple the fixed points taken were: boiling sulphur, 445° C.; the solidification of aluminium, 655° C.; and the solidification of gold, 1,065° C. From the results obtained the solidification point of pure copper is given as 1,085° C. In order to test the influence of oxygen, a series of specimens of varying oxide content were examined, and the results show that as the amount of oxide is increased the temperature of solidification is lowered. Further, a second point is developed on the solidification curve corresponding to the deposition of the eutectic of copper and copper oxide. The opposite table summarises this aspect of the work.

The author's conclusions are as follows:—(1) A digression of from 20 to 25 per cent. is shown between the solidification of pure copper and the eutectic line. (2) The eutectic line is slightly ascendent, starting from 1,060° C. for an oxide content of about 0·6 per cent., and attaining 1,065° C. in the vicinity of the eutectic content. (3) The eutectic content, according to these researches, would be from 4·5 to 5·0 per cent. Cu_2O, and not 3·5 per cent. as indicated by Heyn. Finally, the author notes a method of using copper for calibrating thermo couples which does not introduce serious error. The copper is melted in an open crucible, so that it oxidises freely, and as a result the quantity of eutectic is fairly high. If the fusion is not too long the copper will contain from 2 to 3 per cent. Cu_2O, and the solidification of such a mixture will show two arrests, the second one being very near to a temperature of 1,062° C.

No.	Cu_2O.	Solidification Temperatures.	
		First Point.	Second Point.
	Per cent.	° C.	° C.
1	0·09	1,085	1,055 ?
2	0·18	1,085	1,055 ?
3	0·63	1,082	1,060
4	2·24	1,072	1,060
5	2·40	1,071	1,061
6	2·90	1,070	1,062
7	4·73	1,070	1,063
8	4·73	1,070	1,065
9	5·40	1,067	?
10	6·30	1,072	1,065

The Engineering Press.

List of Journals the principal contents of which are regularly indexed. The papers dealt with are those received between the 10th of the month preceding that of publication and the 10th of the previous month.

American Engineer and Railroad Journal, 140, *Nassau Street, New York* ... ... 20 cts.
American Machinist, 218, *William Street, New York* ... ... 4d.
Annales de l'Association des Ingenieurs sortie de Gand, *Rue Longue du Marais, 15, Ghent*... 2 frs. 30 c.
Australian Mining Standard, 31, *Queen Street, Melbourne* ... ... 6d.
Automobile Club Journal, 119, *Piccadilly, W.* 6d.
Automotor Journal, 44, *St. Martin's Lane, W.C.* 3d.
The Autocar, *Coventry* ... ... 3d.

Beton und Eisen, *Kortorung, 14, Vienna I.* ... 2 marks
British Clayworker, 43, *Essex Street, W.C.* ... 6d.
Bulletin de la Société International des Electriciens, 12 & 14, *Rue de Stael, Paris* ... 2 fr. 50 c.

Canadian Engineer, 62, *Church Street, Toronto* 10 cts.
Cassier's Magazine, *New York* 1/-
Centralblatt für Accumulatoren, *Gross Lichterfelde-West, Bellevuestrasse, 40, Berlin* ... 3 mks. 50 pf. per qt.
Colliery Guardian, 30 & 31, *Furnival Street, Holborn, E.C.* ... ... 5d.
Compte Rendu des Travaux de la Société des Ingenieures Civils de France, 9, *Rue Blanche, Paris* ... ... —
Concrete and Constructional Engineering ...
Der Mechaniker, 113, *Potsdamerstrasse, Berlin, W.* 35 ... ... 40 pf.
Dingler's Polytechnic Journal, *Berlin* .. ... { 3 mos. 6 mrks.

L'Echo des Mines et de la Metallurgie, *Paris*... 45 fr. p.a.
L'Eclairage Electrique, 40, *Rue des Ecoles, Paris* ... ... 1 fr. 50 c.
Electrical Engineer, 139, *Salisbury Court, E.C.* 3d.
Electrical Review, 4, *Ludgate Hill, E.C.* ... 6d.
Electrical Review, N.Y., 41, *Park Row, New York, U.S.A.* ... ... 10 cts.
Electrical Times, 8, *Breams Buildings, Chancery Lane, E.C.* ... ... 2d.
The Electrician, 1/3, *Salisbury Court, E.C.* ... 6d.
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Electricity, 36, *Maiden Lane, W.C.* ... ... 1d.
Electrochemical and Metallurgical Industry, *New York* ... ... 25 cts.
Der Elektro Techniker, *Hengasse, 62, Vienna*... 60 pfs.
Elektrische Bahnen U. Betriebe, 8, *Gluckstrasse, Munich* ... ... { 16 mks. p.a.
Elektrotechnik und Maschinenbau, 7, *Nibelungenstrasse, 7, Vienna* ... ... 20 fr. p.a.
Elektrotechnische Rundschau, *Herderstr, 10a*, 6 mks.
Dusseldorf, ... 6 mos.
Elektrotechnische Zeitschrift, *Monbijonplatz, 3, Berlin, N. 24* ... ... 70 pf.
L'Elettricita, *Via Boccaccio, 5, Milan* ... ... 50 cts.
The Engineer, 33, *Norfolk Street, W.C.*.... ... 6d.
Engineering, 35/36, *Bedford Street, W.C.* ... 6d.
Engineering and Mining Journal, 253, *Broadway, New York* ... . 5 dols. per ann.
Engineering Magazine, 222, *Strand, W.C.* ... 1/-
Engineering News, 220, *Broadway, New York* 15 cts.
Engineering Record, 114, *Liberty Street, New York* ... ... 12 cts.

The Foundry, *Cleveland, Ohio, U.S.A.*.... ... 15 cts.

Gas World, 3, *Ludgate Circus Buildings, E.C.* 4d.
Le Génie Civil, 6, *Rue de la Chaussee d'Antin, Paris* ... ... 1 fr.
Giesserei-Zeitung, *Jerusalemer Strasse*, 46/47, *Berlin, S.W.* ... ... 40 pf.
Gluckauf, *Essen, A. D. Ruhr, Germany* 1 mk. 25 pf.

La Houille Blanche, *Grande-Rue*, 23, *Grenoble* 1 fr. 25 c.

International Marine Engineering, 17, *Battery Place, New York*... ... ... 20 cts.
Iron and Coal Trades Review, 165, *Strand, W.C.* 6d.
Iron and Steel Magazine, 446, *Tremount Street, Boston* ... ... 50 cts.
Iron and Steel Trades' Journal, 5, *Hatton Garden, E.C.* ... ... 3d.
Iron Trade Review, *Cleveland, Ohio* ... ... { 4 dols. 50 c. p.a.

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Journal of the Chemical, Metallurgical and Mining Society, *Johannesburg, S.A.* ... 2/-
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Journal of the Institution of Electrical Engineers, 92, *Victoria Street, S.W.* Single copies vary 1/6-7/6
Journal of the Iron and Steel Institute, 28, *Victoria Street, S.W.* ... ... 16/- per vol. 2 annually
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La Machine, 11 *Rue de la Dole, Geneva* ... ... { 4 frs. 6 mos.
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Nature, *St. Martin's Street, W.C.* ... ... 6d.

Physical Review, *Ithaca, New York, U.S.A.* ... 50 cts.
Power, *World Building, New York* ... ... 20 cts.
Practical Engineer, 287, *Deansgate, Manchester* 2d.
Proceedings of the American Society of Civil Engineers, 220, *West 57th Street, New York* Mbrs. only.
Proceedings of the Canadian Society of Civil Engineers, 112, *Mansfield Street, Montreal* Mbrs. only.
Proceedings of the Engineers' Club of Philadelphia, 1122, *Givard Street, Philadelphia*... 2 dols. per vol.
Proceedings of the Engineers' Society of West Pennsylvania, *Pittsburg, Pa.*... ... ... 50 cts.
Proceedings of the Faraday Society, 82, *Victoria Street, S.W.* ... ... 6d.
Proceedings of the Institution of Civil Engineers, *Great George Street, Westminster* Mbrs. only.
Proceedings of the Institution of Mechanical Engineers, *Storey's Gate, Westminster* ... Mbrs. only.
Proceedings of the Royal Philosophical Society of Glasgow, *Glasgow* ... ... 10/6 p.a.
Public Health Engineer, 50/52, *Ludgate Hill, E.C.* ... ... 3d.
Public Works, 22, *Bride Lane, E.C.* ... ... Qtly. 2/6

Quarry, 49, *Essex Street, W.C.* ... ... 6d.

The Railway Age, *Monadnock Block, Chicago*... 10 cts.
Railway Engineer, 3, *Ludgate Circus Buildings, E.C.* ... ... 6d.
The Railway and Engineering Review, 1305, *Manhattan Building, Chicago* ... ... 10 cts.
Railway Gazette, *Queen Anne Chambers, Westminster* ... ... 6d.
Railway and Locomotive Engineering, 136, *Liberty Street, New York* ... ... 2 cts.
The Railway Master Mechanic, 409, 410, *Security Building, Chicago* ... ... 10 cts.
La Revue de Metallurgie, 75, *Rue Notre Dame des Champs, Paris* ... ... 4 fr. 50 c.
La Revue Technique, Paris ... ... 1 fr.

School of Mines, Quarterly, *Columbia University, New York, U.S.A.* ... ... 50 cts.
Scientific American, 361, *Broadway, New York* 8 cts.

Stahl & Eisen, 5, *Jacobstrasse, Dusseldorf* ... 24 mks. p.a.
The Steamship, 2, *Custom House Chambers, Leith, N.B.* ... ... 6d.
Stevens' Institute Indicator, *Hoboken, N. Jersey* 50 cts.
Street Railway Journal, 120, *Liberty Street, New York* ... ... 6d.

Technology Quarterly, *Institute of Technology, Boston, Mass.* ... ... 75 cts.
"Times" Engineering Supplement ... ... 3d.
Tramway and Railway World, *Amberley House, Norfolk Street, W.C.* 1/-
Transactions of the American Institution of Electrical Engineers, 26, *Cortlandt Street, New York* ... ... Price varies.
Transactions of the American Institution of Mining Engineers, 99, *John St., New York* Price varies.
Transactions of the American Society of Mechanical Engineers, 12, *West 31st Street, New York* ... ... Mbrs. only.
Transactions of the Civil and Mechanical Engineers' Society, *Victoria Street, S.W.* Mbrs. only.
Transactions of the Engineers and Shipbuilders in Scotland, *Glasgow* ... ... Price varies.
Transactions of the Institution of Junior Engineers, 39, *Victoria Street, S.W.* ... —
Transactions Liverpool Engineering Society, *Royal Institution, Liverpool* ... ... —
Transactions N.E. Coast Institution Engineers and Shipbuilders, *Newcastle-on-Tyne* ... —
Transactions of North of England Institution of Mining and Mechanical Engineers, *Newcastle-on-Tyne* ... ... —
Transactions of the Society of Engineers, *Victoria Street, S W.* ... ... Mbrs. only.
Transactions Society of Manchester Engineers, 29, *Brown Street, Manchester* ... ... —

Western Electrician, *Chicago* ... ... 10 cts.

Zeitschrift des Oestereichischen Ingenieur und Architekten Vereines 1, *Exchenbachgasse, Vienna*, 9... ... ... 70 h.
Zeitschrift des Vereines Deutscher Ingenieure, *Berlin* ... ... 1 m. 40 pf.

Civil Engineering.

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Working of the Simplon Tunnel. *Engineer*, *22nd June*, 1906.

Reinforced Concrete Bridges. By W. Noble Twelvetrees. *Concrete and Constructional Engineering*, *July*, 1906.

The Anatomy of Bridgework, XIV. By W. H. Thorpe. *22nd June*, 1906.

Viaduct over the River Barrow, near Waterford. By Sir Wm. Arrol & Co., Ltd. *Engineering*, *15th* and *29th June*, 1906.

The Cross River Dam in the Croton Watershed. Description of an Unusual Method of Construction employed on the New York Waterworks. *Engineering Record*, *16th June*, 1906.

A New Method of Calculating Bridge Stresses under Wheel Loads. *Engineering News*, *21st June*, 1906.

A Diagram for Bridge Laterals. By O. W. Childs. *Engineering News*, *21st June*, 1906.

The Progress of the Quebec Bridge. *Engineering Record*, *23rd June*, 1906.

Empirical Formulas for Reinforced Arches. By D. B. Luten. *Engineering News*, *28th June*, 1906.

Cantilever Bridge of 1,800 ft. span, across the St. Lawrence, *Engineering*, *6th July*, 1906.

Building.

Mechanical Compression of the Ground in the Construction of Foundations. *Scientific American*, *9th June*, 1906.

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Heating and Ventilating Plant of the Indianopolis Post Office and Custom House. *Engineering Record*, *9th June*, 1906.

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Reinforced Concrete in France. By M. de Ledesco. *Concrete and Constructional Engineering*, *July*, 1906.

The Setting of Portland Cement, II. By E. Candlot. *Concrete and Constructional Engineering*, *July*, 1906.

The Theory of Rein orced Concrete. By Capt. Sewell. *Concrete and Constructional Engineering*, *July*, 1906.

Tests of the Strength and Fireproof Qualities of Sand-Lime Brick. *Engineering News*, *14th June*, 1906.

Decay of Stones in Buildings: The Cause and Prevention. *The Quarry, July*, 1906.

Investigation of the Thermal Conductivity of Concrete and the effect of Heat upon its Strength and Elastic Properties. By Ira H. Woolson. *Engineering News, 28th June*, 1906.

Boilers, Furnaces and Fuel.

Coke and Ore Bins. By E. W. Pittman. *Proceedings Engineers Society, West Pennsylvania, June*, 1906.

Suction Gas Producer Trials, I., II. *Engineer, 15th* and *22nd June*, 1906.

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The Formation of Rings in Cement Kilns. *Engineering Record, 16th June*, 1906.

The Intelligent Use of Boiler Compounds. *Engineer, Chicago, 15th June*, 1906.

The Use of Alcohol as a Fuel for Gas Engines. By H. Diederichs. *International Marine Engineering, July*, 1906.

New Method of Determining Heating Values of Gas. Paper by M. R. Casaubon before Société Technique du Gaz en France. *Gas World, 30th June*, 1906.

Recent Niclausse Boiler Plants. *Steamship, July*, 1906.

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Mechanical Stoking Economics. By A. S. Atkinson. *Engineer, Chicago, 2nd July*, 1906.

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Some Comparisons of Steam Turbines and Reciprocating Engines. *Mechanical World, 22nd June*, 1906.

Design, Construction, and Application of Large Gas Engines in Europe, VIII. *Power, June*, 1906.

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Air Compressors and Blowing Engines. By C. H. Innes, M.A. *Practical Engineer, 15th* and *29th June*, 1906.

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The Light Machine Shop: Its Proportions and Equipment. By E. H. McClintock. *Machinery, June*, 1906.

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Designing a Boring Mill *American Machinist, 16th June*, 1906.

Worm Gear Design. By A. M. Sosa. *American Machinist, 16th June*, 1906.

The "Gleason" Automatic Bevel-gear Generating Planer. *American Machinist, 7th July*, 1906

Miscellaneous Mechanical Subjects.

Strength of Wire Rope. *Power, June*, 1906.

Coal-handling Plant of the Long Island City Power House of the Pensylvania Railroad. *Power, June*, 1906.

Allowable Unit Loads on Knife Edges for Testing Machines and Heavy Weighing Scales. By J. W. Bramwell. *Engineering News, 14th June*, 1906.

Design of Condensing Plant, X. *Mechanical World, 15th June*, 1906.

Collapsing Pressures of Bessemer Steel Lap-Welded Tubes, *Machinery, June*, 1906,

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Some Speculation on the P.R.R. Tests. *Railway and Engineering Review, 9th June*, 1906.

Signalling in the Electric Zone, N.Y.C. and H.R.R.R. *Railway and Engineering Review, 9th June*, 1906.

Development of Valve and Valve Motion, IV. By A. Sinclair. Combined Link and Cam Motion. *Railway and Locomotive Engineering, June*, 1906.

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Freight Car Construction and its Commercial Aspect. *American Engineer and Railroad Journal, June*, 1906.

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Cast Iron Wheels. *Railway Gazette, 22nd June*, 1906.

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Burton and Ashby Light Railway. *Railway Magazine, July*, 1906.

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Notes on the Lighting of Churches. By E. R. Weeks before Annual Convention of American Institution Electrical Engineers, 31st May. *Western Electrician, 2nd June*, 1906.

Some Physiological Factors in Illumination and Photometry. Dr. Louis Bell before Illuminating Engineering Society, N.Y. 8th June. *Western Electrician, 16th June*, 1906.

The Flaming Carbon Arc Lamp. Abstract from paper by L. B. Marks before National Electric Light Association, N.J., 5th June, 1906. *Western Electrician, 16th June*, 1906.

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The Power Transmission Line and Third Rail System of the Long Island Railroad, I., II. *Street Railway Journal, 9th* and *16th June*, 1906.

Series Parallel Armature Windings with Equipotential Connections. By Prof. E. Arnold. *Electrician, 15th June* and *6th July*, 1906.

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Bloomington, Pontiac and Joliet Single-Phase Line. By John R. Hewett. *Street Railway Journal, 16th June*, 1906.

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Electric Winding. By W. C. Mountain before Institute of Mining Engineers. *Colliery Guardian, 22nd June*, 1906.

Electrically-Driven Air Compressors combined with Heading Machines. By Mr. A. Thompson before Institute of Mining Engineers. *Colliery Guardian, 22nd June*, 1906.

Electrolytic Corrosion of Structural Steel. *Electrochemical and Metallurgical Industry, June*, 1906.

The Classification of Alternate-Current Motors. By V. A. Fynn (*concluded*). *Electrician, 15th June*, 1906.

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The Testing of a Low Resistance by means of Ordinary Laboratory Instruments. By G. W. Burley. *Electrical Engineer, 15th June*, 1906.

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Marine Engineering and Naval Architecture.

His Majesty's Battleship *Agamemnon*. *Engineering, 22nd June*, 1906.

The Stability of Submarines. By Sir Wm. H. White. *Marine Engineer, 22nd June*, 1906.

Propellers. By A. E. Seaton, VI., VII. *Marine Engineer, 22nd June* and *6th July*, 1906.

Launching of the French Armoured Cruiser *Ernest Renan*. *International Marine Engineering, July*, 1906.

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New Battleship Designs: A Powerful Russian Design. *International Marine Engineering, July*, 1906.

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Motor Boats, XIII.: Power and Speed. *International Marine Engineering, July*, 1906.

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Reinforced Concrete Water Mains. R. H. Wyrill. *Concrete and Constructional Engineer, July*, 1906.

Notes on Sprinkling Filters for Sewage Treatment: A Résumé of American and Foreign Experience. By Geo. W. Fuller. *Engineering Record, 23rd June*, 1906.

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Bacterial Tank Operations. By W. Owen Travis, M.D., read at the Civil and Mechanical Engineers' Society, 3rd May, 1906. *Public Health Engineer, 16th June*, 1906.

Sludge Treatment in Relation to Sewage Disposal. By J. D. Watson. *Public Health Engineer, 7th July*, 1906.

Streets and Pavements.

Concrete Pavements in Chicago. *Engineering Record, 9th June*, 1906.

Engineering Economics and Works Management.

The Commercial Organisation of Engineering Factories, IX. By H. Spencer. *Engineer, 22nd June*, 1906.

Cost-Keeping for Small Works. By G. Martin Gamble. *Mechanical World, 29th June*, 1906.

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Mercurous Sulphate and the Standard Cells. By G. A. Hulett. *Physical Review, June*, 1906.

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The Structural, Municipal and Sanitary Aspects of the Central Californian Disaster, II., III. *Engineering Record, 9th* and *16th June*, 1906.

Labour-Saving Appliances in the Works-Laboratory. By Ed. Keller. *Transactions American Institute of Mining Engineers*, Vol. xxxvi., 1906.

The Effect of Impurities on the Electrical Conductivity of Copper. By Lawrence Addicks. *Transactions American Institute of Mining Engineers*, Vol. xxxvi.

BOOK NOTICES.

Modern Polyphase Machinery. By ANDREW STEWART, A.M.I.E.E. (London: S. Rentell & Co., Ltd., 36, Maiden Lane, W.C.) Price, 5*s.* net.

This handy little volume, the subject-matter of which originally appeared as a series of articles in *Electricity*, forms an excellent and easily understood introduction to the subject of polyphase machinery. It makes no pretence of dealing with the subject in an exhaustive manner, and mathematics have been introduced only in so far as is necessary to correctly understand alternating current phenomena.

Students and engineers who wish to make themselves generally familiar with the characteristics of polyphase machinery will find the work distinctly helpful.

The illustrations are clear, and a fair index is provided.

Practical Motor Car Repairing. By ERIC W. WALFORD. (London: Percival Marshall & Co., 26–29, Poppin's Court, E.C.) Price, 1*s.* net.

A distinctly practical handbook, and one which will be found of invaluable aid to drivers and owners in diagnosing and dealing with the small roadside troubles and mishaps which inevitably occur.

The "Timber Trades Journal" Timber Trades Directory. (London: W. Rider & Sons, Ltd., 164, Aldersgate Street, E.C.) Price, 7*s.* 6*d.* net.

This work is the only classified directory of the timber trades published, and is arranged in five sections. The first is devoted to London, and consists of classified lists of the various trades; the next deals with England and Wales; the two following ones with Scotland and Ireland, and the last with foreign countries. A special feature of this new edition is the series of carefully prepared official plans of all the principal docks and harbours in the United Kingdom.

Technical Dictionary in Six Languages. Volume I. "The Machine Elements and the Most Frequent Tools for Metal and Wood Working." (London: Archibald Constable & Co., Ltd., 16, James Street, Haymarket, W.) Price, 5*s.* net.

Those who find it necessary or who possess the time and inclination to study or read technical articles and books in the principal modern languages, will appreciate without our saying it, that the *bête noir* of this form of mental exercise is the absence of any really useful and adequate technical dictionary. In such dictionaries as are to be had, it appears to be the English side that is always so badly rendered, and even in the volume under notice – the first of a series of technical dictionaries for engineers—this defect is by no means absent; on the whole, however, this dictionary is excellent; we welcome it, and cordially recommend it.

There is one new and useful feature employed, viz.: the use of drawings, diagrams, and formulæ which considerably assist the definition and remove ambiguity.

The arrangement is also good, viz.: an index; a systematic arrangement of the matter, and finally, an alphabetical index of words, the latter comprising the German, English, French, Italian, and Spanish languages, Russian having its own separate index.

The first portion, classified according to subject, is well done, enabling an engineer, with a knowledge of any particular branch, to easily find what he wants, and afterwards to translate this into the terms of any other language. The first volume is limited to Machine Elements and Tools, and eleven others, specialized with regard to subject-matter, for example, Electrical Engineering, Steam Engineering, Hydraulic Machinery, &c., are to follow shortly. They will be welcomed.

Dictionary of Engineering Terms, in English and Spanish, with Indexes in both Languages. By A. J. GARCIA. (London: Hirschfeld Bros., Ltd., 13, Furnival Street, Holborn, E.C.) Price, 3*s.* 6*d.* net.

This little work suffers from the defect that it attempts too much, the portion dealing with electrical engineering being particularly weak.

A reader of Spanish would, however, probably find it, generally speaking, useful.

The Indicator Handbook. By CHAS. N. PICKWORTH, Wh.Sch. Part I. The Indicator: its Construction and Application. Third edition. (Manchester: Emmott & Co., Ltd., 65, King Street.) Price, 3*s.* net.

This, the third edition of this well-known and greatly appreciated handbook, has been brought up-to-date, by including descriptions of various forms of Continuous Indicators, including the "Cipollina" instrument. From the same publishers we have received a copy of the 10th edition of PICKWORTH'S "SLIDE RULE" (2*s.* net), the popularity of which needs no attesting on our part. A deal of new matter has been included in the new edition, more especially in connection with new forms of slide rules, and of a series of special instruments of recent introduction.

BOOKS RECEIVED.

The Geometry of the Screw Propeller. By Wm. J. Goudie, B.Sc., A.M.I.,Mech.E. (London: Blackie & Son, Ltd., 50, Old Bailey.) Price, 1s. 6d. net.

Joiners' Machines and How to Work them. By T. R. Groom. (London: Wm. Rider & Son, Ltd., 164, Aldersgate Street, E.C.) Price, 1s. net.

Bridges: Notes on the Acquisition, Construction, Works and Maintenance of the County Bridges, Tunnels, Ferry, Embankments, and River Prevention of Floods Works in the County of London, together with descriptive and Explanatory Notes on the Structure, Works and other Technical Matters. By Maurice Fitzmaurice, C.M.G., M.A., Chief Engineer and County Surveyor. Prepared, under the direction of the Bridges Committee of the Council, by the Clerk of the Council. (London: P. S. King & Son, 2 & 4, Great Smith Street, Victoria Street, S.W.) Price, 6d. net.

Steam Turbine Engineering. By T. Stevens, A.M.Inst.C.E., A.M.I.E.E., and H. M. Hobart, B.Sc., M.I.E.E. (London: Whitaker & Co., 2, White Hart Street, E.C.) Price, 21s. net.

CATALOGUES.

American Locomotive Co., New York. *Locomotive Tests—Pennsylvania Railroad:* A compilation by Dr. W. F. M. Goss from the recent publication by the Pennsylvania Railroad, describing the locomotive tests and exhibits of that road at the Louisian Purchase Exhibition, has been issued by the American Locomotive Co. This pamphlet presents, in concise form, an account of the locomotive tests at St. Louis, giving specific information concerning each of the locomotives tested, and presenting the results separately for each of the eight locomotives. In the pamphlet four pages are devoted to a description of each locomotive and a discussion of its performance, including a summary of the data of the tests. This is followed by comparisons and conclusions compiled by Dr. Goss from the very elaborate record of the tests issued in book form by the Pennsylvania Railroad. While the pamphlet does not add to the information given in the book, it presents the conclusions and comparisons in form for convenient reference. This pamphlet will give a very wide distribution to a summary of the important records of the testing plant at St. Louis. For a more complete record, the book published by the Pennsylvania Railroad may be consulted, than which there is nothing more valuable in recent literature of the locomotive.

Also, an advance copy of a pamphlet entitled "Electric Motor and Trailer Trucks."

Bateman's Machine Tool Co., Ltd., Hunslet, Leeds. Catalogue illustrating and describing the sole specialty of this firm, viz., High-Speed Planing Machines. These machines have been designed to take full advantage of high-speed steels when on the "cut" stroke, and make the return stroke at correspondingly high speeds. This is accomplished in the following way:—The machines are fitted with patented fly-wheel loose pulleys, for use with overlapping belt, and with an automatic friction clutch between the fly-wheel and fast pulley, of which there is one on either side of the machine for cut and return.

The belts being wider than the fixed pulleys, overlap on to the fly-wheel pulleys when thrown over to do their share of the work, and through this overlap obtain much of the conserved energy of the fly-wheel at the moment it is most required.

The friction clutches are actuated by the belt-shifting arrangements, and further assist the fast pulleys in obtaining conserved energy from the fly-wheel loose pulleys, reducing the time of acceleration of the table and making the machine remarkably prompt.

Another fitting consists of a patent sliding rack, which has a short longitudinal motion in a groove on the underside of the table. To a cross-head at one end of this sliding rack spindles are secured carrying adjustable springs, These springs absorb all the shock of reversal, and so enable these machines to be run at high speeds.

Ernest Scott and Mountain, Ltd., Newcastle-on-Tyne. A very useful pamphlet, prepared by Mr. W. C. Mountain, respecting the Home Office Regulations as regards the use of electricity in mines.

A great deal of misconception appears to exist in the minds of mining engineers and colliery owners as to the electricity rules, and it occurred to the author that a simple explanation as to how these rules could be carried out without undue expense would be welcomed.

These pamphlets are sold at 2s. 6d. each. Besides the rules, they contain a large amount of useful information, such as power tables, cable carrying capacities, loss in pipes both for air and water, and other general information, which will be of great value to mining engineers.

Crompton & Co., Ltd. List V. 13 of electrical instruments for continuous current circuits. They are all of the moving coil type, and can be left continuously in circuit without undue heating. Also an abbreviated price list of electrical machinery, including arc lamps, C.C. dynamos, alternating current generators, polyphase and single-phase motors, switchgear and instruments.

Also list P. 26, dealing with projectors.

Cambridge Scientific Instrument Co., Ltd., Cambridge. List No. 39. Technical thermometry, descriptive of electrical resistance thermometers, thermo-electric thermometers, Féry radiation and absorption pyrometers, continuous temperature recorders, electrical resistance furnaces, &c.

Alfred Herbert, Ltd., Coventry. 1906 Second Edition Catalogue, Section E. Modern capstan lathes. Also a copy of the firm's Milan catalogue, printed specially for the "Milan International Exhibition, 1906," at which Messrs. Herbert are exhibiting.

The Fireproof Co., Ltd., York Buildings, Adelphia. Circular respecting the Dovetail Corrugated Sheet Steel Damp Course.

NOTES.

The "Kleine" Patent Flooring, 9, St. Helen's Place, E.C. An opportunity was recently afforded us of witnessing a test made with this system of flooring at the Imperial Hotel, Southampton Row, W.C., now under construction. The span of the floor tested was 12 ft., one end resting on top of a girder, the other on top of a brick wall.

The floor itself is constructed of rectangular hollow bricks measuring 10 in. by 6 in. by 4 in., laid alternately flat and on edge. The brick slab was thus in the shallow rows 4 ins. and in the deep rows 6 ins. thick. The top of this brick slab, which had an iron tension band embedded in each joint, was covered with ballast concrete alternately 1 and 3 ins. thick, thus bringing the total thickness of the flooring to 7 ins. The addition of this concrete is required for the necessary strength in compression, and the corrugated surface of brick slab by bricks placed alternately flat and on edge produces a good bond for the concrete, preventing all shearing.

The floor was loaded in four oblong spaces in the centre portion. Each space measured 7 ft. by 5 ft. 3 in. The total load was 22 tons, equal to 3 cwt. per foot super.

The floor was constructed for a load of 1 cwt. per foot super, with a factor of safety of 4, and when the floor was loaded to the above weight the architect and owner of the hotel were satisfied.

The deflection, which was measured on the plastered soffit of the ceiling below, showed a maximum of $\frac{7}{16}$ of an inch. The plaster showed no cracks whatever, and on the load being removed the floor returned to its original perfectly level position.

To this may be added, that the flooring and roofs built on this construction in the Imperial Hotel, when finished, will represent an area of over 8,000 yards super; that the flooring has been widely adopted on the Continent, particularly in Germany, on account of its fire-resisting and sound-proof qualities, up to the present time over 10,000,000 yards having been constructed.

"Off for the Holidays" is the title of a pictorial poster by which the Great Central Railway Company draws the public attention to their arrangements for the holiday season, and an examination of their A B C programme demonstrates that this enterprising company has done everything possible to provide for the holiday traveller. For those wishing to visit the bracing health resorts on the North-East coast, tickets are announced every Saturday during the season, covering a period from three to seventeen days, for 17*s.* to Cleethorpes, or 21*s.* to Scarborough and Filey. Similar tickets are issued to the West Coast watering-places, viz., to Southport and Liverpool for 19*s.*, to Blackpool, Lytham, St. Anne's, and Fleetwood for 21*s.*, and to Douglas (Isle of Man) for 23*s.* 6*d.* and 27*s.* 6*d.* Every Thursday cheap tickets for sixteen days are obtainable to all the principal health and pleasure resorts in Ireland. Cheap tickets are also issued every Saturday for three, six, or eight days to over two hundred towns and places in the Midlands, Yorkshire, Lancashire and North of England. In the majority of cases the fare for an eight days' ticket is less than a sovereign. Such low fare tickets are, however, not offered to the detriment of comfortable and expeditious travel, as passengers are allowed to perform the journey by express trains, composed of up-to-date corridor stock, and a buffet car is attached for the provision of meals on the train at a most reasonable tariff.

For those desirous of spending a pleasant day or a week-end in the country, facilities are announced suitable for all tastes. There are day and half-day excursions to many delightful spots in Herts and Bucks, and for the pedestrian and cyclist over forty tours have been arranged, many of them covering fresh ground now accessible by the opening of the new suburban line into Buckinghamshire. Lovers of Shakespeare are given the opportunity of visiting Stratford-on-Avon three days a week, at a special inclusive fare; for the modest sum of 14*s.* the journey to Stratford is covered, including two drives, luncheon and dinner.

Every Friday and Saturday week-end tickets, available by any ordinary train, are issued to all the inland and seaside holiday resorts, extending from the Midlands to the North of Scotland.

These arrangements are conveniently tabulated in the form of an A B C excursion programme, obtainable, free of cost, at Marylebone Station, N.W., or at any of the Company's town offices and agencies situated throughout London and suburbs.

Record Single Order for Gas Engines. The Indiana Steel Company has given the largest single order for gas engines ever placed by one company. It is for eight "Westinghouse" twin-tandem, double-acting, horizontal gas engines of 3,000 h.-p. each, capable of delivering 30,000 cubic feet of free air per minute to the furnaces which produce the blast furnace gas which, in its turn, is also used to operate the engines.

Battersea Polytechnic. The governing body have appointed to the position of head of the Department of Electrical Engineering, Mr. A. W. Ashton, M.Sc., of the University of Leeds. Mr. Ashton is a Whitworth Exhibitioner, an 1851 Exhibition Scholar, and he obtained his B.Sc. in electrical engineering with honours at the Durham College of Science in 1898, afterwards graduating M.Sc. During the college vacations, he worked in different departments of Messrs. Siemens & Co., of Charlton, and prior to his appointment at Leeds was for five years assistant to the manager of the Helsby Cable Company, at Runcorn, where he also conducted evening classes in electrical and other engineering subjects.

H.M.S. *Gadfly*. On Friday, June 29th, the coastal destroyer *Gadfly*, built by Messrs. J. I. Thornycroft & Co., Ltd., of Chiswick, made a satisfactory preliminary contractor's trial on the measured mile at the Maplin. This is the first of the twelve boats of this new type to make a steam trial, and although the weather was very unfavourable, wind and sea both being high, a speed of 26·05 knots (the contract speed being 26 knots), was obtained, with a load on board rather in excess of that which she will have, in the middle eight hours' official trial. The vessel is fitted with Parson's turbines and oil fuel apparatus, and considerable interest therefore attaches to the trial.

New Arrol-Johnston Car Company, Ltd., of Underwood, Paisley. The colonial trade of this firm continues to be well maintained. Among recent orders received, are several from Rangoon,

Ceylon and New Zealand. The chief demand is for 12-15 h.-p. cars and chars-a-banc, although the other types of pleasure and industrial vehicles manufactured by the firm in question are also selling well.

The "R. A. S. E." Suction Gas Plant Trials. Messrs. the Campbell Gas Engine Co., Ltd., Halifax, write as follows:—"We shall feel much obliged if you will grant us a little space in your correspondence columns to place before your readers some facts concerning the above trials and the awards which have been made by the judges in connection with them. We have felt so strongly over this matter that we have entered an official protest against these awards being made.

"The printed regulations of the R. A. S. E. set forth the special points to which their attention will be given, and these are as follows:—1. Attendance necessary. 2. General design, including facility of cleaning and space occupied. 3. Regularity of running. 4. Fuel consumption; water consumption. 5. Price. 6. Relative proportion of gas producer and engine. 7. Volume swept by piston relative to brake h.-p.

"The above regulations were the special points on which the awards were to be based, and we have respectfully protested that such points had not been duly considered in connection with the gas engine and gas plant which the judges selected for their trial on Saturday, the 23rd June last, along with the engines of Messrs. Crossley Bros., and the National Gas Engine Co., Ltd. The grounds of our protest are as follows:—

"(1) *Attendance necessary.* We have pointed out that in our gas engine and gas plant we had only one attendant who performed all the work in connection with the starting and running, whereas the two successful engines had, at least, two attendants to do the same work. Further, the time taken by our attendant throughout the trial to start our gas engine and gas plant was about 50 per cent. less than the time taken by either of the above two firms.

"(2) *General Design, Including Facility of Cleaning and Space Occupied.* As to the general design of the engine, we claim for it that it is considerably in advance of any of the engines entered for competition, for the following reasons:—

"(*a*) The extended bedplate supporting the engine cylinder practically the whole of its length.

"(*b*) The facility with which the ignition of the engine can be advanced or retarded while the engine is at work to suit the kind of gas being used at any time. This important feature does not exist in either of the two successful engines. (*c*) The ring lubrication fitted to the crankshaft bearings. (*d*) Forced lubrication fitted to the engine piston.

"Other details, such as the waste oil trough round the engine bedplate and loose exhaust valve seats and loose guides for the exhaust valve spindles, might also be mentioned.

"As to the general design of the gas plant, the following special points should be noticed: (*a*) The superheater used is of the most simple character, and one which permits its being cleaned in a very easy manner. (*b*) The generator is fitted with a cast-iron base, preventing either internal or external corrosion, and gives a much longer life than one made of steel-plate. (*c*) Every detailed part of our gas plant and pipe connections is fitted with loose doors through which each part can be cleaned. The gas plants of the successful engines have not any doors fitted on the pipe connections, and bends in their gas plants, and to enable the interior of their scrubbers to be examined, cleaned or filled the main gas pipe has to be entirely removed, an operation entirely unnecessary in our gas plant.

"*Space Occupied.* We emphatically claim that our gas engine and plant can be put into less space than either of the successful competitors as an examination of this will prove.

"(3) *Regularity of Working.* We claim that our gas engine and gas plant has proved more regular in working than either of the successful competitors. The gas made by the plant was regular in quality, and did not necessitate any adjustment of the air throttles from time to time. The engine worked in a very regular manner, though it was fitted with less weight of flywheel than any of the two successful engines.

"(4) *Fuel Consumption, Water Consumption.* As to fuel consumption we are unaware what amount of fuel was consumed by the successful competitors, but we do know that consumed by our engine and plant. If none of the coal taken out of the generator and unused by us be credited to us, our coal consumption is 1·20 lb. per brake h.-p. per hour; if all such coal be credited to us, our consumption is 1 lb. per brake h.-p. per hour. The consumption of coke used in our engine was 1·25 lb. per brake h.-p. per hour if the coke returned be credited. Such fuel consumptions as these will compete at least favourably with those of the successful plants, but it has to be specially noticed in this connection that the judges told the competitors that fuel consumption was not the most important feature of the trials.

"As to water consumption, we made no special effort to reduce this in the trial, believing that the conditions to be observed were to be such as would be obtained in ordinary every day work. Our water consumption under these conditions works out to one and a half gallons per brake h.-p. per hour. Such consumptions could easily be reduced if necessary at the expense of having dirty valves, dirty piston, and a dirty cylinder.

"The other three points in the regulations issued by the R. A. S. E. do not call for notice here.

"We beg to say in conclusion that the engine exhibited by us was one of our standard character, and had nothing of the purely racing element about it. It was one which could be safely put in the hands of an unskilled person.

"On the above grounds we have protested against the awards which have been made, and we feel most strongly that, if such decisions as these are to be characteristic of future trials of the R. A. S. E., no competitor can have any assurance that his machine or implement will receive that careful treatment to which he is at least entitled.

"In consequence of our having submitted our official protest we have received from the secretary to the R. A. S. E. the following reply:—

"'I am instructed to acknowledge the receipt of your letter of the 28th instant respecting the awards made by the judges in the suction gas plant trials at this show.

"'The protest was formally reported to the Council at their meeting held yesterday in the showyard, and instructions given for your letter to be submitted to the judges and the Society's consulting engineer for their observations and report for consideration by the Council.'

"We leave the matter here for the present, and we ask for your indulgence in placing this matter before your readers, as we know that others besides ourselves who entered the competition feel as strongly as we do in this matter, and that it is not simply our own feeling which prompts us."